

From the Division of Obstetrics and Gynecology
Department of Clinical Science, Intervention and Technology
Karolinska Institutet, Stockholm, Sweden

Go with the Flow
To Facilitate Learning in Laparoscopic
Gynecology

Liv Ahlborg



**Karolinska
Institutet**

Stockholm 2013

All previously published papers we reproduced with permission from the publishers.

Cover; Ebba Karlsson Ahlborg

Published by Karolinska Institutet

.© Liv Ahlborg, 2013, ISBN 978-91-7549-198-1

To whom it may concern

“Klart att vi vill ha bättre flow”

Joel Lundqvist, Tre Kronor, maj 2013

ABSTRACT

Background

Education in medicine, particularly in surgical disciplines, is crucial since it affects patient safety. The learning process is dependent on individual abilities, prior knowledge and the learning environment.

Evidence of simulators' positive impact on actual laparoscopic performance is mounting. However, less attention has been given to non-technical factors that might have direct effect on both simulated and real laparoscopic performance.

Aims of the thesis

1. To evaluate if visuospatial ability, as measured by the Mental rotation test A, correlates with gynecological simulated laparoscopic performance (paper I)
2. To examine if self-efficacy and flow are associated with simulated laparoscopic performance (paper II)
3. To investigate if visuospatial ability, self-efficacy, flow and simulator training in LapSimGyn®, with or without mentorship with feedback influence performance in laparoscopic tubal occlusion (paper III)
4. To evaluate the effect of mentorship with feedback on simulated laparoscopic performance using both quantitative and qualitative methods (paper IV)

Materials and methods

The participants in the studies were consultants or residents in obstetrics and gynecology or medical students. Validated tests, questionnaires and scales assessed visuospatial ability, self-efficacy and flow. Simulator training was conducted in LapSimGyn®. Laparoscopic performance was measured as duration of surgery in the laparoscopic tubal occlusions. Group interviews and inductive thematic analyses were used to evaluate mentorship.

Results

This thesis demonstrates that visuospatial ability correlated with duration of surgery in early gynecological laparoscopic simulator performance ($r: -0.64$, $p < 0.05$) as well as in early laparoscopic performance ($\rho: -0.98$, $p < 0.05$), Papers I-III.

Simulator training appeared to enhance both self-efficacy and flow, Papers II & III. Moreover, the findings suggested that laparoscopic performance was improved by simulator training with, or without, structured mentorship and by increased flow and self-efficacy among the trainees. Duration of surgery was significantly shorter in the trained groups (median 340 s, IQR: 285-537) as compared to the control group (median 760 s, IQR: 573-1218), Paper III. Mentorship with feedback influenced laparoscopic simulator performance. Right instrument path length was shorter in the mentor group (median 3.9 m, IQR: 3.3-4.9) as compared to the control group (median 5.9 m, IQR: 5.0-8.1). Students in the mentor and non-mentor groups expressed the importance of getting support and being acknowledged, Paper IV.

Conclusions

Simulator training, supportive mentorship with feedback, visuospatial ability, self-efficacy and flow are all tools or factors that have the potential to facilitate learning in gynecological laparoscopy and improve the surgical performance. Creating a learning environment with these factors in mind might therefore lead to improved patient safety.

LIST OF PUBLICATIONS

- I. Ahlborg L, Hedman L, Murkes D, Westman B, Kjellin A, Felländer-Tsai L, Enochsson L.
Visuospatial ability correlates with performance in simulated gynecological laparoscopy
European Journal of Obstetrics & Gynecology and Reproductive Biology.
2011, 157: 73-77.
- II. Ahlborg L, Hedman L, Rasmussen C, Felländer-Tsai L, Enochsson L.
Non-technical factors influence laparoscopic simulator performance among OBGYN residents
Gynecological Surgery. 2012, 9: 415-420.
- III. Ahlborg L, Hedman L, Nisell H, Felländer-Tsai L, Enochsson L.
Simulator training and non-technical factors improve laparoscopic performance among OBGYN residents
Submitted
- IV. Ahlborg L, Weurlander M, Hedman L, Nisell H, Lindqvist PG, Felländer-Tsai L, Enochsson L.
Evaluation of structured mentorship and learning during simulated laparoscopic training
Submitted

TABLE OF CONTENTS

1	INTRODUCTION	1
2	BACKGROUND	2
2.1	LEARNING	2
2.2	LAPAROSCOPY	3
2.3	PATIENT SAFETY	4
2.4	SIMULATOR TRAINING	6
2.5	VISUOSPATIAL ABILITY	9
2.6	SELF-EFFICACY	10
2.7	FLOW EXPERIENCE	12
2.8	MENTORSHIP AND FEEDBACK	13
2.9	SUMMARY	15
3	AIMS	16
3.1	GENERAL AIM	16
3.2	HYPOTHESES AND SPECIFIC AIMS	16
4	MATERIALS AND METHODS	17
4.1	PARTICIPANTS	17
4.2	STUDY DESIGNS	17
4.3	SIMULATOR	19
4.4	MENTAL ROTATION TEST-A	20
4.5	SELF-EFFICACY	21
4.6	FLOW	21
4.7	CHECKLISTS MENTOR	22
4.8	QUALITATIVE METHODS	22
4.8.1	DATA COLLECTION	23
4.8.2	DATA ANALYSES	23
4.9	STATISTICAL ANALYSES	23
5	RESULTS	25
5.1	PRIMARY FINDINGS IN EACH STUDY	25
5.2	OVERALL RESULTS	25
5.2.1	SIMULATOR TRAINING EFFECT	25
5.2.2	MENTAL ROTATION TEST-A	28
5.2.3	FLOW AND SELF-EFFICACY	28
5.2.4	MENTOR EFFECT	29
5.2.5	FOCUS GROUP RESULTS	30
6	DISCUSSION	31
6.1	METHODOLOGICAL CONSIDERATIONS	31

6.1.1	PARTICIPANTS	31
6.1.2	INTERNAL VALIDITY	31
6.1.3	EXTERNAL VALIDITY	32
6.1.4	LOSS TO FOLLOW UP	32
6.1.5	SIMULATOR TRAINING AND PERFORMANCE	33
6.1.6	LAPAROSCOPIC PERFORMANCE	35
6.1.7	MENTAL ROTATION TEST-A	36
6.1.8	FLOW	36
6.1.9	SELF-EFFICACY	36
6.1.10	QUALITATIVE METHOD	37
6.1.11	STATISTICAL CONSIDERATIONS	38
6.1.12	ETHICAL CONSIDERATIONS	38
6.2	GENERAL DISCUSSION	39
6.3	CONCLUSIONS, IMPLEMENTATIONS AND FUTURE PERSPECTIVES	42
7	POPULÄRVETENSKAPSKAPLIG SAMMANFATTNING	44
7.1	BAKGRUND	44
7.2	SYFTE	46
7.3	MATERIAL OCH METODER	46
7.4	RESULTAT	46
7.5	SLUTSATSER	47
8	ACKNOWLEDGEMENTS	48
9	REFERENCES	50

LIST OF ABBREVIATIONS

CPR	Cardiopulmonary resuscitation
MRT	Mental rotation test
OBGYN	Obstetrics and Gynecology
OR	Operating room
VR	Virtual reality

1 INTRODUCTION

“My hands are trembling (lack of self-efficacy, negative mentor effect).

What am I supposed to do? (lack of prior knowledge, lack of feedback from mentor, lack of flow). Oh, I cut the wrong structure. I couldn’t judge the distance (lack of prior training, visuospatial inability). The patient is bleeding, bleeding a lot, oh gosh (lack of patient safety). He takes over. Is the patient going to bleed to death? I will never become a surgeon (possible fatal effect on both patient and resident’s future ability to learn)”.

Discouraged 2nd-year resident in obstetrics and gynecology, 2006

In brackets, interpretations by author

These are the reasons why I got engaged in facilitating learning in laparoscopic gynecology.

2 BACKGROUND

2.1 LEARNING

Learning is complex. The learning process is dependent on individual abilities, prior knowledge, the learning environment and defined goals. In the first half of last century behaviorists believed that learning was a process built on stimuli and responses. Several scientists reported that learning was motivated exclusively by external forces like hunger, rewards or punishments [1, 2].

In the late 1950s, a new field emerged, cognitive science. Cognitive science approached learning from a multidisciplinary perspective that included anthropology, linguistics, philosophy, developmental psychology, computer science, neuroscience, and several branches of psychology [3].

According to cognitive science, the student needs to get *involved* and actively participate in the learning process in order to learn. The key factor to involvement is *motivation*. Biggs states; “There is no such thing as unmotivated students, all students not in coma want to do something” [4]. The best chance of achieving motivation is by engaging intrinsic factors, such as *fascination and challenge* in the students, in contrast to external factors like rewards, *e.g.* fame or money.

Challenges, however, must be at the proper level of difficulty in order for the person to be, and to remain, motivated: tasks that are too easy become boring; tasks that are too difficult cause frustration [4]. This is in line with Csikszentmihalyi’s definition of the *flow experience* [5].

Prior knowledge of the task or topic will facilitate this process [3, 4].

“With a history of successful engagement with content that is personally meaningful, the student both builds up the knowledge base needed for deep learning and, motivationally, develops the expectations that give confidence in future success: what are known as feelings of what psychologists call self-efficacy or more simply ‘ownership’: ‘I can do this; this is my thing.’” [4]. *I.e. self-efficacy* is another factor important for the learning process.

Ericsson *et al.* stress the essence of prolonged practice and *repetition* in learning. Characteristics previously believed to represent innate abilities or talent are actually the result of intense practice, often during a decade or more. Learning in repetitive practice is reported to be enhanced by *feedback* [6].

The learning environment can facilitate or obstruct the learning process by influencing these factors (in italics above). Among many things, the teacher or *mentor* can have a profound influence on the learning process [4].

The learning process in surgery is of particular importance since it affects patient safety.

2.2 LAPAROSCOPY

The word *laparoscopy* originates from ancient Greek lapara meaning "flank, side", and skopeó, meaning "to see". It is an operation performed through small incisions (usually 0.5–1.5 cm), with the aid of a camera, within the abdominal cavity. Laparoscopy can be used to inspect and diagnose a condition or to perform surgery, *e.g.* tubal occlusion (sterilization), salpingectomy or cholecystectomy.

Even Hippocrates (469-375 B.C.) had a desire to investigate the inside of a patient with minimal harm [7]. But it was not until after Thomas Edison's invention of the incandescent light (1879), that surgeons were finally able to examine the abdominal cavity through a scope [7]. George Kelling was the first to perform this procedure, in 1901, on a dog. In 1910, Hans Christian Jacobaeus, a professor of internal medicine, in Stockholm, first used this technology on a living human. Laparoscopy was thereby invented [8].

Clinical laparoscopy, however, did not become practical until the 1960's when the gynecologist Kurt Semm introduced an automatic device for insufflation of the abdomen. Semm and Raul Palmers are the fathers of modern gynecological laparoscopy. Palmer is considered to be the first laparoscopist to understand the crucial importance of monitoring and controlling the pressure from insufflation

[9] .

The introduction of the computer chip video camera in the late 1980's was another important innovation contributing to the evolution of laparoscopy. In the 1990's laparoscopy became the gold standard for cholecystectomy [10].

In gynecology, the laparoscopic approach is nowadays the first choice in the majority of, at least benign, abdominal procedures. This development has been driven by the lesser surgical trauma inflicted on the patients, faster post-operative recovery, shorter absence from work and also the fact that it is cosmetically more pleasing than traditional, open, surgery [11].

There are, however, as in all invasive interventions, complications associated with laparoscopic surgery. These complications are partly due to factors that differentiate laparoscopy from open surgery [12]. For instance, in laparoscopy the learning curve for novices is longer than in open surgery, the time in surgery is longer and the entry to the abdomen is blind [13, 14]. Furthermore, particular abilities are needed in laparoscopy compared to open surgery. It primarily concerns psychomotor and perceptual skills. For example, converting the two-dimensional image you see on the video monitor into a three-dimensional picture in your mind, when performing laparoscopy [15-17]. Moreover, the long instruments used together with the abdominal walls displacement of the instrument's movement axis makes the coordination of the instrument more challenging, *i.e.* the fulcrum effect [18]. Fulcrum is the point of support on which a lever turns. Haptic (pertaining to the sense of touch) feedback is also impaired in laparoscopy compared to open surgery.

Since these factors are critically relevant for patient safety, they need to be considered to optimize learning in laparoscopy.

2.3 PATIENT SAFETY

The training of surgeons is rooted in apprenticeship methods developed over a century ago, as originally championed by William Halsted in 1904 [19]. The “*see one, do one, teach one*” surgical training method is, however, associated with

unacceptable cost from a patient safety perspective. Although this approach has fostered excellent surgeons we can suspect at the expense of patient safety. There is now ample evidence to suggest that more structured training programs can in fact enhance patient safety.

Innovative medical educators set a beginning to the end of the Halsted paradigm in the 1980s with the introduction of skills-training for surgical discipline residents in a laboratory environment [20].

In 1999, the Institute of Medicine (IOM) Committee on Quality of Health Care in America's report "**To Err Is Human: Building a Safer Health System**" was released. The IOM committee reported that between 44,000 and 98,000 Americans die every year as a result of medical errors occurring in hospitals. The economic cost of preventable adverse events in the U.S. was calculated to range between \$17-\$29 billion. The public response to this report was instant. President Bill Clinton directed his health care quality task force to provide feedback within 60 days on how his administration could implement the recommendations made by the IOM [21].

In Sweden, an estimated 100 000 preventable medical errors occur during 1,2 million admissions for somatic care per year [22].

The advent of dramatic changes in surgical technology, as illustrated by the increase in laparoscopic procedures since the 1990s, has forced surgeons to explore alternatives to traditional educational models, largely in response to patient safety concerns [23].

The demand for evidence-based practice, not only in clinical practice, but also in medical education is becoming increasingly evident. For this reason, accreditation of medical training centers is a key issue. Checklists, certified CME (continuing medical education), and pedagogical portfolios are tools used to achieve structure and development in medical training. Hafford *et al.* recently reported that certification in the fundamentals of laparoscopic surgery may

become necessary to ensure competency also for those surgeons already in laparoscopic practice [24].

While most research on laparoscopic education has been conducted within the field of general surgery, gynecology has been the subject of far fewer studies. Consultants and residents in obstetrics and gynecology (OBGYN) usually share their working hours between the disciplines obstetrics and gynecology and therefore spend far less time in the operating room (OR) as compared to their fellow surgeons in most other surgical disciplines. Hence, alternative training-tools for learning and maintaining proficiency in laparoscopy is of particular importance for gynecologists.

An increasing number of research reports suggest that simulators can effectively allow trainees to acquire new skills outside of the operating room [25-28]. The implementation of surgical simulators in clinical practice is thus one potential avenue for improving patient safety.

2.4 SIMULATOR TRAINING

A simulation, according to Mc Gahghie is; "...a person, device, or set of conditions which attempts to present evaluation problems authentically. The student or trainee is required to respond to the problems as he or she would under natural circumstances. Frequently the trainee receives performance feedback as if he or she were in the real situation." [29].

Virtual reality (VR) is a term that refers to computer-simulated worlds or realities. The main factor, influencing learning, that differentiates a virtual simulator from a "black box" or a "box-trainer", is that the simulator provides feedback. It documents and measures all instrument movements. The simulator demonstrates the possible improvements and the learning curve. VR simulation in medical education has evolved during the last 30 years and taken an even greater place as a safe practice training method during the last decade [30].

Simulation technology has a long tradition in a variety of disciplines and professions such as flight simulations for pilots and astronauts, war games for the military and management games for business executives [29]. In medicine, simulators are also used in a variety of fields involving clinical topics such as airway management, central venous catheter insertion, emergency training with CPR (cardiopulmonary resuscitation), gastrointestinal endoscopy, endo-urology arthroscopy and laparoscopy [31-37].

When discussing medical simulators, a few key terms need to be introduced.

Validity is in simple words accuracy, *e.g.* how accurately a tool trains what it is purposed to train or measures what it is purposed to measure. *Reliability* is continuancy, *e.g.* if a tool repeatedly gets the same result.

Construct validity tells if a test or a tool for example differentiate an expert from a novice. In other words can it measure different levels of competence or performance?

Face validity describes the subjective, usually an expert's, opinion on if the tool "looks/ feels like the real thing".

Predictive validity determines if the tool, in this case the simulator, delivers transfer of skills, to the OR.

MIST-VR® was the first commercial endoscopic simulator, which became available less than 20 years ago. This simulator provided training in basic skills without anatomical graphics or haptic feedback. Seymour *et al.* first demonstrated the potential effect of this simulator in 2002. This study reported that errors were six times less likely to occur among simulator trained surgical residents, performing laparoscopic cholecystectomy, compared to an untrained group [36]. *I.e.* skills appeared to have been transferred from simulator training to the operating room. Similar results were found in studies that followed [38] indicating reliability. Proficiency levels were established and construct validity determined [39].

Subsequent simulators like LapMentor® and LapSim® introduced full laparoscopic procedure training, *e.g.* cholecystectomy and salpingectomy with

anatomic graphics and the possibility of haptic feedback. This was a great improvement since the trainees could now, not only learn how to handle the instruments, but also learn how to perform the actual procedure. Construct validity for LapSim® was established [40]. Several studies have also reported transfer of skills for LapSim® [41-43].

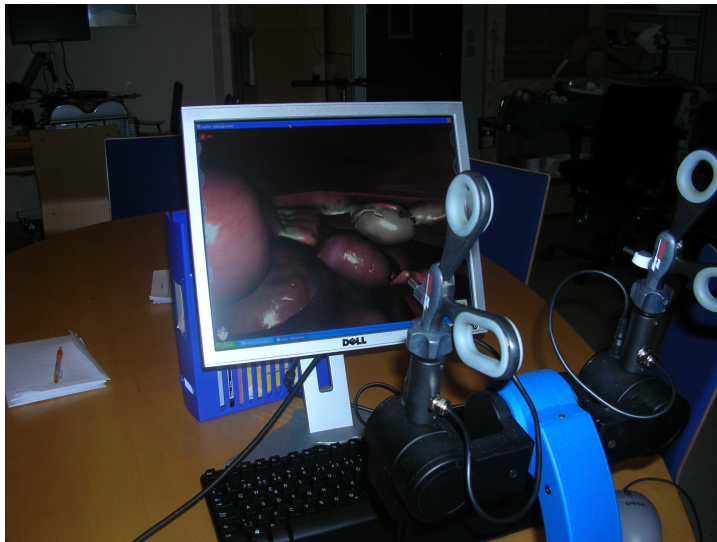


Figure 1. LapSim®. Illustrating instrument handles and screen view of “salpingectomy” with ectopic pregnancy.

Training in advanced medical simulators appears to be beneficial for enhancing the technical performance among residents in surgery, urology and obstetrics and gynecology (OBGYN) [36, 41, 43, 44] with improved patient safety as a consequence [45].

Laparoscopic simulators are, however, expensive. The price of an advanced laparoscopic simulator ranges between €40,000 and €130 000 [46], and they are therefore often located to larger academic centers, available primarily for novices located at these centers or for residents attending courses, perhaps only once during their entire residency. With this in mind, we may ask; Are there factors that could enhance or boost simulator training? Are there factors that are correlated to simulator training that could be trained elsewhere?

2.5 VISUOSPATIAL ABILITY

Cognitive abilities can be divided into sub-groups, like *reasoning ability*, *visuospatial ability* and *memory*, collectively often referred to as general intelligence. Working memory refers to the temporary storage and manipulation of information necessary for cognition [47]. Visuospatial ability, is defined as pertaining to visual perception and the spatial relationship between objects, or the capacity to generate “a mental presentation of two- or three- dimensional structures and then assessing its properties or performing a transformation of the representation” [48]. Macmillian *et al.* identified aspects of surgical performance that showed no apparent improvement with practice, indicating that some innate abilities can ultimately predict the level of operative skills [49]. Visuospatial ability has been linked to a variety of surgical and medical skills [17, 27, 50-52].

During laparoscopy, you need to convert the two-dimensional picture on the video monitor into a three-dimensional picture in your mind in order to properly judge the distance and direction from the instrument to an object in the abdomen [15-17]. Visuospatial ability and working memory are both reported to correlate with *simulated* endoscopic and *simulated* laparoscopic performance [17, 34, 51]. A potentially controversial issue is whether assessment of visuospatial ability should be used to identify those particularly suited for laparoscopic surgery or to identify those with greater needs for training.

Visuospatial ability can be reliably measured in individuals by tests such as the mental rotation test (MRT) which is commonly used in cognitive science [53] (see also method chapter).

It has been reported that children with attention-deficit hyperactivity disorder ADHD can improve their *working memory* by cognitive training [54]. Another study suggests that cognitive training improve working memory in adults [55]. However, it is more controversial if visuospatial ability can improve with cognitive training. While some investigations indicate that individuals with impaired abilities; *e.g.* Alzheimers disease or stroke patients benefit from training [56, 57], another study reports that visuospatial ability is resistant to

the influence of *e.g.* video game playing [58]. Several studies, however, report on correlations between visuospatial ability and video or computer game playing [59, 60]

It remains to be established if visuospatial ability correlates to gynecological simulated laparoscopy and more importantly to the actual laparoscopic performance. Furthermore, it remains to be established if it is useful to evaluate this ability in order to personalize learning in laparoscopic gynecology.

2.6 SELF-EFFICACY

Another important factor for the learning process is self-efficacy. This term is commonly defined as “*what you believe you can do with the skills that you have*” [61]. To distinguish between self-efficacy and self-esteem, perceived self-efficacy can be defined as judgments of one’s personal capability, whereas self-esteem concerns judgments of one’s self-worth [61].

It is obvious that all individuals can influence their own performance on a given task. However, human behavior is determined, in most situations, by several interacting features. So individuals are often influencers rather than predictors of how things turn out. Many of our actions are carried out with intentions that are often diametrically different from the actual outcome of these actions. The power to execute actions for a given purpose is the key factor of personal capacity. Self-efficacy appears to be a key feature of human capacity or potential [61].

Collins (1982) studied children who judged themselves to be of high or low self-efficacy at different levels of mathematical ability. Within each level of ability, children who scored high on their perceived self-efficacy were sooner to discard faulty strategies, solved more problems, chose to re-work failed tasks more eagerly, and did so more accurately than children of equal ability, but who scored low (doubted) on their efficacy [61].

Motor learning and performance require much more than mastering physical skills. There are countless examples of athletes who despite great physical skills

fail to achieve or deliver according to their abilities in demanding situations, *i.e.* are not “clutch”. Efficacy beliefs are essential in the development of motor skills and how well they are executed under pressure. Belief in one’s abilities to, learn the patterns of the action and successfully deliver them, contribute independently to better performance [61]. The learning environment can also contribute to perceived self-efficacy. Prior knowledge or skills affect self efficacy as well as personal goals [62], see Figure 2.

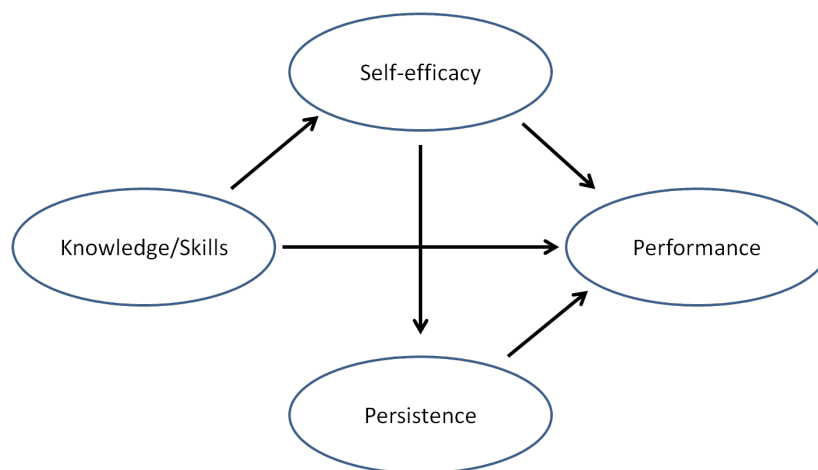


Figure 2. Self-efficacy in learning.

One study report that students in medicine and para-medicine improve their self-efficacy when training inter-professionally compared to traditional clinical training [63]. Maschuw *et al.* reported that simulator novices with perceived low self-efficacy also performed poorly in a laparoscopic simulator [64]. Thus, if training programs can assess and improve self-efficacy among students, residents and surgeons, these training programs can potentially contribute to learning and patient-safety. It remains, however, to be established if self-efficacy is associated with gynecological simulator performance and the actual laparoscopic performance.

2.7 FLOW EXPERIENCE

“When in flow an individual operates at full capacity” [65]. Experiencing flow is to move or progress smoothly with unbroken continuity, with concentration and complete absorption in what you do. Flow depends on perceived action-capacities and opportunities. The balance between capacity and opportunity is, however, delicate. If a challenge begins to exceed skills, you eventually become anxious, if skills begin to exceed challenge, you relax and run the risk of becoming bored [65]. The capacity to experience flow appears to be universal across different cultures and disciplines. However, there seem to be certain personalities that foster flow. An “autotelic” personality is defined as somebody who enjoys life and tend to do things for their own sake rather than to achieve external goals. This type of person is generally curious with low self-centeredness and a higher ability to enter a state of flow than other types of personalities [5]. Research also reports that there are individuals that have a stronger urge to enter a state of flow and therefore often seek it [66].

The flow experience is suggested to facilitate learning by encouraging you to take on more difficult tasks, promoting creativity, increasing the joy during an activity and creating meaning of involvement in an activity [5, 67].

According to Nakamura and Csikszentmihalyi, the experience of flow motivates a person to return to that activity and thereby enhances development of skills over time [65], see Figure 3.

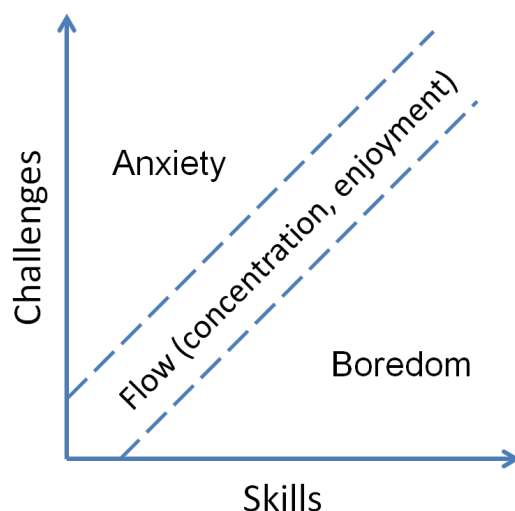


Figure 3. Illustration of flow experience, based on Csikszentmihalyi [65].

Games and sports are examples of activities that facilitates the experience of flow by providing goal and feedback structures [65].

Based on these assumptions, it is reasonable to believe that flow could also facilitate learning in simulated and real laparoscopy, but this remains to be established.

2.8 MENTORSHIP AND FEEDBACK

Another factor in the learning environment is the mentor. Mentorship has a long-standing tradition in all forms of training/education. What characterizes good mentorship or good teaching, however, remains controversial.

The interactions between disciplinary knowledge and pedagogical knowledge contradicts common misconceptions about what skills teachers need in order to design feasible learning environments for their students. The misunderstanding is that a good teacher can teach any subject, or that content knowledge alone is sufficient [3].

“Many universities, accepting that teaching is no longer the poor cousin of research, have responded positively with an increasingly teaching-friendly environment. It is increasingly being recognized that good teaching is as much a function of an institution-wide infrastructure as it is a gift with which some lucky academics are born.” [4].

Ahlberg *et al.* conclude that when evaluating surgical residents’ performance in laparoscopic fundoplication, the teachers competence is, in fact, the most influential factor [68]. A skilled teacher or mentor can improve a resident’s performance while a less skilled mentor can even worsen it. In light of this observation, training and experience in mentorship in surgery deserve greater emphasis. There is clearly need for specific, targeted training since doctors who have no experience from teaching often lack confidence in this area. Training in providing mentorship has therefore been suggested to be offered to new consultants [69].

Similar to mentorship, the idea of feedback has a long-standing tradition.

Feedback, as part of medical teaching, is mentioned already in the writings of Hippocrates and other physicians in ancient Greece [70].

Feedback is defined as: *"Specific information about the comparison between a trainees observed performance and a standard, given with the intent to improve the trainees performance."* [71].

Van de Ridder *et al.*, conclude that feedback in medical education is crucial but that there is no consensus on how to provide it. Unfortunately, studies on the subject report that while medical educators frequently believe they give feedback, trainees state that feedback is rare [71]. One study report that although 90% of attending surgeons believed they gave feedback sufficiently only 17% of their residents agreed with this assertion [72].

Inasmuch as it has been evaluated, some studies suggest that structured mentorship with feedback improves the simulated and the real endoscopic and laparoscopic performance [30, 73-75]. Others, however, report that an independent approach, without mentorship, in simulated laparoscopy, might actually better facilitate learning [76]. In these studies is not always clear how feedback has been given.

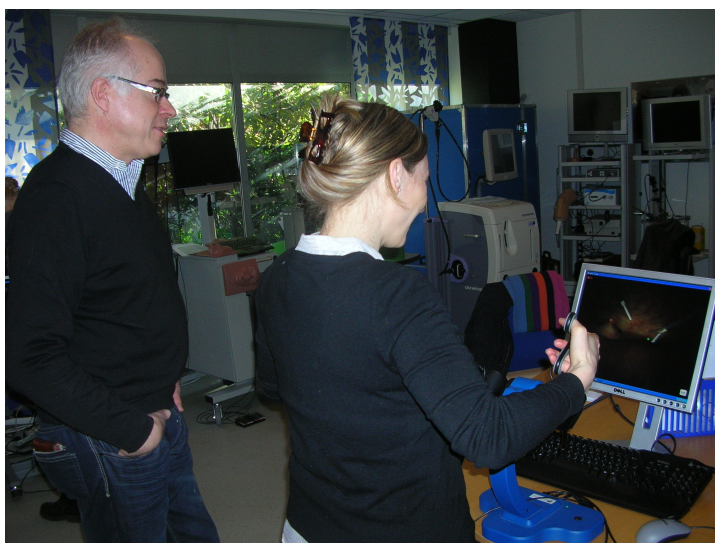


Figure 4. Simulator training in LapSim® with mentor.

Some studies evaluate feedback supported by review of the surgery from a video tape [74]. This type of feedback is presumably effective but time-consuming and usually not feasible in clinical practice.

Thus, while it is reasonable to assume that both mentorship and feedback are good things in surgical training, the shapes and forms of these factors remain to be established.

2.9 SUMMARY

Patient safety is a top priority in health care.

All surgical procedures are potentially hazardous.

Systematic surgical education can reduce risks associated with surgery.

Evidence for the benefits of simulator training in learning laparoscopy is mounting.

Learning is complex and the benefits of developing and improving non-technical skills need to be investigated in relation to simulator training and surgery.

Mentorship is available at all clinics but often lacks structure. Feedback appears to be important for learning, but how it should be provided to be feasible to implement in clinical practice remains to be established.

3 AIMS

3.1 GENERAL AIM

The general aim of this thesis was to facilitate learning in laparoscopic gynecology.

3.2 HYPOTHESES AND SPECIFIC AIMS

The hypotheses for my thesis were:

1. Visuospatial ability determines gynecological simulated and laparoscopic performance
2. Self-efficacy and flow are associated with simulated laparoscopic performance
3. Self-efficacy and flow influence laparoscopic performance
4. Simulator training improves laparoscopic performance among OBGYN residents
5. Mentorship with feedback improves simulated and real laparoscopic performance

To test these hypotheses, we conducted four studies with the following specific aims:

1. To evaluate if visuospatial ability as measured by the MRT-A correlates with gynecological simulated laparoscopic performance (paper I)
2. To examine if self-efficacy and flow are associated with simulated laparoscopic performance (paper II)
3. To investigate if visuospatial ability, self-efficacy, flow and simulator training in LapSimGyn®, with or without mentorship with feedback influence performance in laparoscopic tubal occlusion (paper III)
4. To evaluate the effect of mentorship with feedback on simulated laparoscopic performance by both quantitative and qualitative methods (paper IV)

4 MATERIALS AND METHODS

4.1 PARTICIPANTS

The participants in these studies were all volunteers who could at any time chose to terminate their involvement. Subjects were consultants in OBGYN (paper I), residents in OBGYN (papers II & III) and medical students attending an OBGYN undergraduate course (paper IV). For detailed information, see manuscripts. The same group of residents constituted the study population in the second and third studies. The prior experience of simulator training and laparoscopy was equal across groups in papers II- IV.

4.2 STUDY DESIGNS

Designs of the individual studies are illustrated below, see Figures 5-8.

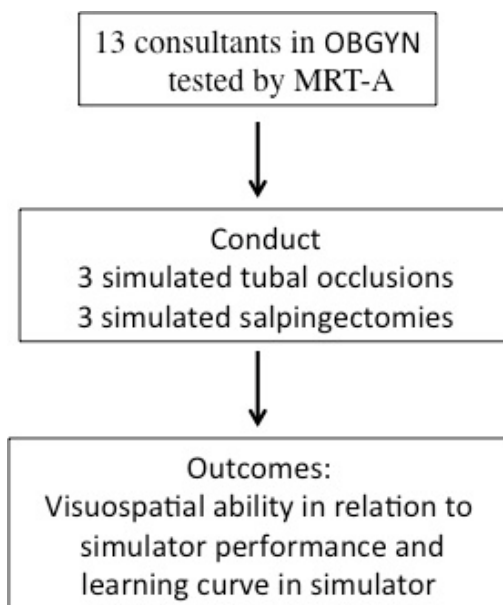


Figure 5. Study I.

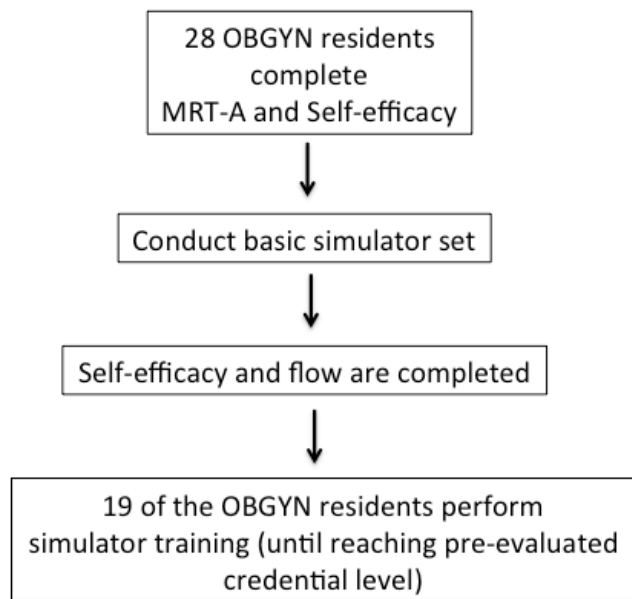


Figure 6. Study II.

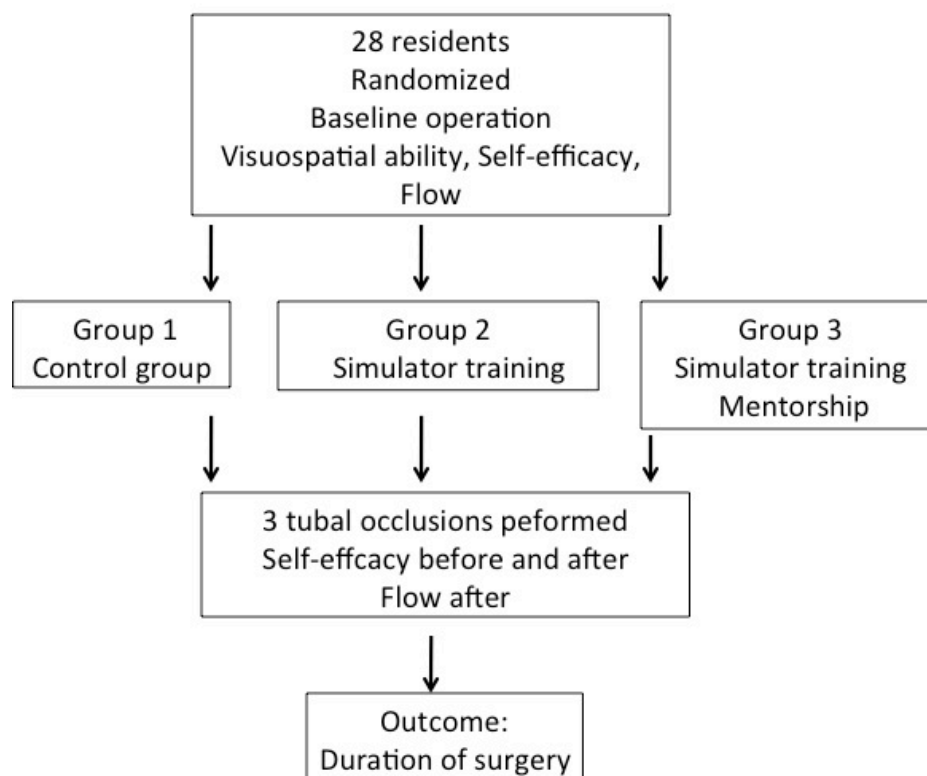


Figure 7. Study III.

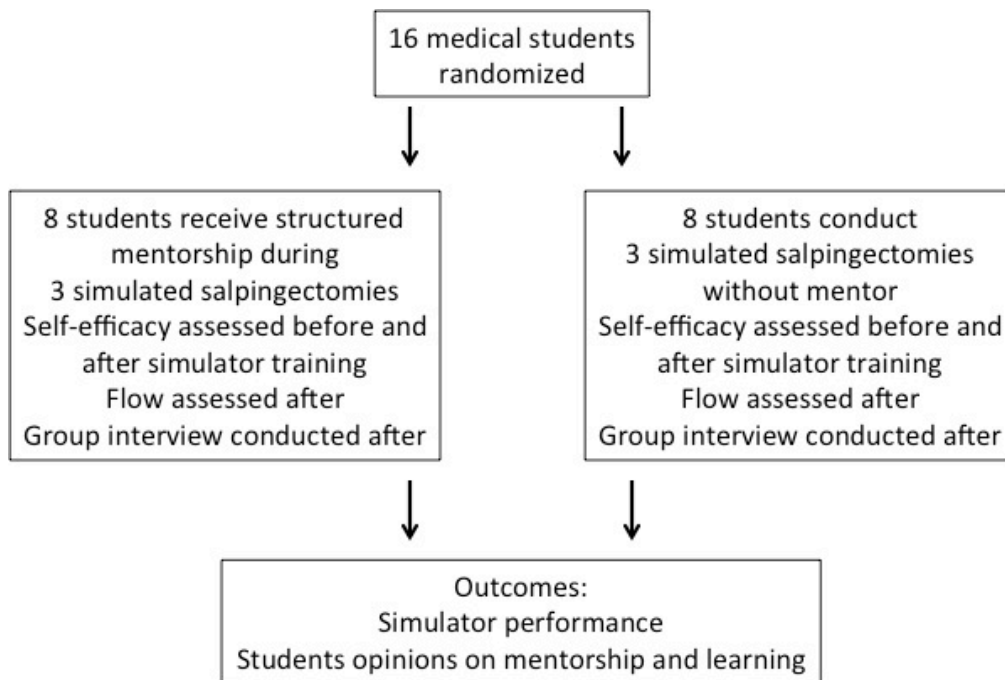


Figure 8. Study IV.

4.3 SIMULATOR

Simulator training in these studies was conducted at the Center for Advanced Medical Simulation and Training (CAMST), Karolinska University Hospital, Stockholm and at Södertälje hospital, Södertälje, Sweden.

For laparoscopic gynecological simulation, we used the LapSim®Gyn VR (virtual reality, Surgical Science AB, Gothenburg, Sweden) simulator, which is an advanced laparoscopic simulator with proven construct validity [40, 42, 77]. The system consists of software that runs on a Xeon-1.8 GHz processor using Microsoft Windows® XP (Microsoft Corporation, Redmond, WA, USA). The computer is equipped with 256 MB of internal RAM, a NVIDIA Quadro2 EX graphics card (NVIDIA Corporation, Santa Clara, CA, USA), a 15-inch monitor, and a virtual laparoscopic interface manufactured by Immersion, Inc. (San Jose, CA, USA).

In the first study the subjects performed two procedures; tubal occlusion and salpingectomy.

To measure the simulator performance in these studies, the parameters; total time (s), score (%), ovarian diathermia damage (s), instrument path length (m)

and angular path (degrees) were analyzed. Total time was the duration of each task. Score was the equally weighted score values of right and left instrument path lengths (m) and angular paths (degrees), instrument misses (%), time (s), blood loss (ml), bleeding (ml/s), distance of tube cut from uterus (mm), ovarian diathermia damage (s) tissue damage (#) and max damage (mm).

In the first study consultants conducted the tasks “tubal occlusion” and “salpingectomy”. The parameters total time, score and ovarian diathermia damage determined performance in this study.

In the second and third studies, subjects performed five different tasks; “tubal occlusion”, “salpingectomy”, “clip applying”, “cutting” and “lifting and grasping”. These tasks constituted a set of tasks with a predefined credential level [40, 78]. In these studies, left and right instrument path lengths and angular paths illustrated baseline performance. To evaluate simulator performance after two days of training, the numbers of trials conducted to reach credential levels in all tasks and specifically in “lifting and grasping” were counted.

In study IV, students conducted “tubal occlusion” and “salpingectomy”. Right instrument path length in the task “salpingectomy” was measured to evaluate simulator performance.

4.4 MENTAL ROTATION TEST-A

In order to test visuospatial ability, participants in studies I-III completed the redrawn Vandenberg and Kuse Mental Rotations Test, version A [53]. This test consists of 24 items, each containing a target figure to the left with four stimulus figures to the immediate right of the target figure, see Figure 9. The task for the test subject is to mentally rotate the stimulus figures around the vertical axis. Participants had to identify both of two correct alternatives, in order to get a score of “1”. Thus, the maximum score was 24. Each participant was given the items organized into two subsets consisting of 12 items each. Three minutes were given to complete each subset with a one-minute break between each part. Instructions, procedures and scoring were all identical to those of Peters *et al.* [53].

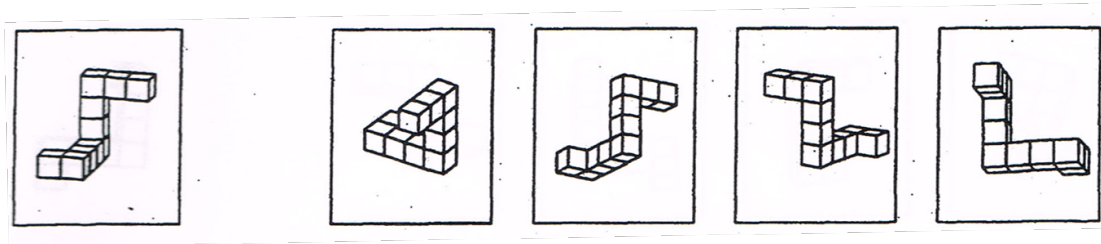


Figure 9. Selected item from the MRT-A test [53].

4.5 SELF-EFFICACY

In studies II-IV we used a shortened version of a self-efficacy questionnaire developed by Pintrich *et al.* [67].

This questionnaire consisted of three items, each rated on a 7-grade Likert-type scale. The items were:

1. I am confident that I can handle the most difficult parts of the tasks during the simulator training/ future simulator training
2. I will comprehend the meaning of the simulator tasks/ future simulator tasks.
3. I am confident I will succeed in future simulator tasks.

Self-efficacy was calculated as the sum of all items [67].

4.6 FLOW

In study II, we used a flow questionnaire based on Ghani and Deshpande [79].

Four categories of flow were self-assessed (enjoyment, four items; concentration, four items; control, three items; exploratory use, four items). A flow score was calculated as the sum of all items. In studies III and IV we used a version of the same scale, including only the two categories, most relevant for the flow experience, *i.e.* enjoyment (Figure10) and concentration.

The following questions ask about your feelings while using computers in a certain medical simulation. Please describe the last session while using the present simulator by placing check mark on the scale given below

Enjoyment

Interesting	_____	Uninteresting
Fun	_____	Not fun
Exciting	_____	Dull
Enjoyable	_____	Not enjoyable

Figure 10. Components of the flow category enjoyment.

4.7 CHECKLISTS MENTOR

As mentor checklists in study III we used:

1. A checklist prior to surgery including patient specific items and procedure specific items
2. A checklist after surgery with items of feedback, *e.g.* “Did the procedure go according to plan?”, “Were there any complicating factors?”, “What parts went well?”, “What parts did not go well?”, “Could anything be improved for the next procedure?”

4.8 QUALITATIVE METHODS

Mentorship in study IV was interpreted not only by quantitative methods (by measuring the parameters in the simulator), but also by qualitative methods. Since mentorship is somewhat controversial we wanted to explore students views on this matter by using group interviews.

Qualitative content analysis originates from research in communication and is described as a flexible method for analyzing text data [80]. Qualitative thematic and content analyses describe, interpret and find patterns or themes in the data [81, 82]. This method has been criticized for only describing the data and therefore to be too simplistic [83]. Despite this criticism, qualitative methods are

widely used, since they are flexible in nature and can be used to interpret data and find underlying meanings otherwise difficult to illustrate or hypothesize [81, 82]. Qualitative content analysis involves interpretation of data at several stages during the analyses and evaluates both the manifest (what is explicitly said) and the latent (the underlying meaning) content [81, 84].

4.8.1 Data collection

Two groups were interviewed using a semi-structured approach. The mentor and the non-mentor groups were interviewed separately a few weeks following simulator training. Both males and females were represented at the interviews. Participants were asked to broadly describe their experience. We asked open questions to stimulate reflection. Examples of questions that were asked: "What did you experience?", "What did you learn?", "Did you get enough support?", "Did the situation appear authentic?", "How would you design this type of training?"

4.8.2 Data analyses

The data was approached by inductive thematic analyses [82]. We went beyond what was explicitly said and interpreted the latent content. Initially we inductively categorized the manifest content into codes and subsequently we described the latent content as themes [81]. Themes were discussed and agreed upon by two researchers.

4.9 STATISTICAL ANALYSES

Data analyses were carried out using JMP® version 9.0.0 (SAS Institute Inc., Cary, NC, USA) for Mac OS X® version 10.5.7 (Apple Inc., Cupertino, CA, USA).

Linear regression analysis was used to analyze the relationship between visuospatial ability and simulated laparoscopic performance. ANOVA was used to analyze differences of performance in the simulator between the different sessions (paper I).

Pearson's correlation was used to analyze the relationship between visuospatial ability, self-efficacy, and flow, respectively, and simulated

laparoscopic performance. Student's t test was used to investigate differences in self-efficacy mean scores between the different sessions of simulator training (paper II).

Spearman's correlation was used to analyze the relationship between visuospatial ability and flow respectively and laparoscopic performance. Mann-Whitney U or Kruskal-Wallis tests were used to evaluate differences in self-efficacy, flow scores and simulated or surgical performance between two or three groups, respectively (papers III & IV).

A p-value <0.05 was considered statistically significant.

5 RESULTS

5.1 PRIMARY FINDINGS IN EACH STUDY

- I. Visuospatial ability correlated positively with *simulated* gynecological laparoscopic performance among consultants (See Fig. 1, paper I).
- II. Self-efficacy and flow correlated positively with *simulated* laparoscopic performance among OBGYN residents (See Table 2, paper II).
- III. Visuospatial ability correlated with early *real* laparoscopic performance and flow correlated with *real* laparoscopic performance among OBGYN residents. Self-efficacy and flow were enhanced during surgery among simulator-trained groups, as compared to the untrained group (See Fig. 4-7, paper III).
- IV. Mentorship with feedback had a positive effect on laparoscopic *simulator* performance among medical students. Feedback and acknowledgement were important factors according to qualitative analyses (See Fig. 1, paper IV). See also Table. 1 below.

5.2 OVERALL RESULTS

In this section I will try to tie results from the different studies together and compare results between different study populations.

5.2.1 Simulator training effect

Consultants, already practicing laparoscopy, as well as residents, improved their performance when training in a laparoscopic simulator (Fig. 2, paper II).

All residents in study II reached the credential level, defined by experts.

When training over a longer period of time, to a credential level, the performance appeared to be independent of the visuospatial ability, *i.e.* anyone can potentially reach the “expert level” with the proper number of repetitions in the simulator.

The performance during the two-day training course, *i.e.* the number of trials to reach credential level, did not significantly correlate to the visuospatial ability (paper II), see Figure 11.

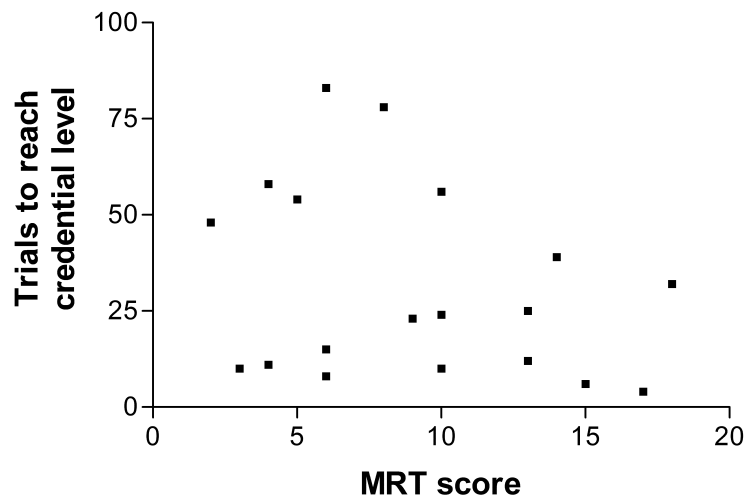


Figure 11. Visuospatial ability vs. simulator performance.

The base-line simulator (Figure 12) and baseline laparoscopic performances (Figure 13) for residents in study II and III were equal across groups. The base-line simulator performance among students in paper IV was also equal across groups (Figure 14).

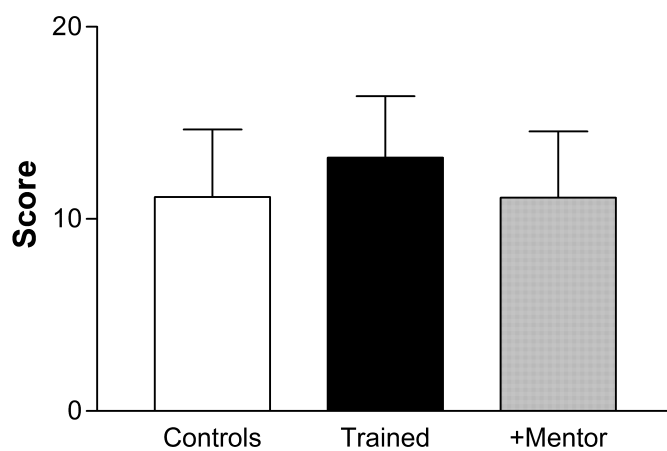


Figure 12 . Basic simulator performance across groups. Study III.

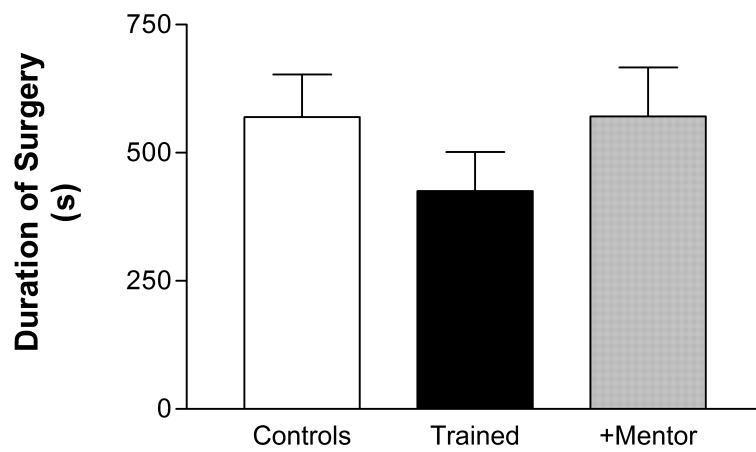


Figure 13 . Basic laparoscopic performance across groups. Study III.

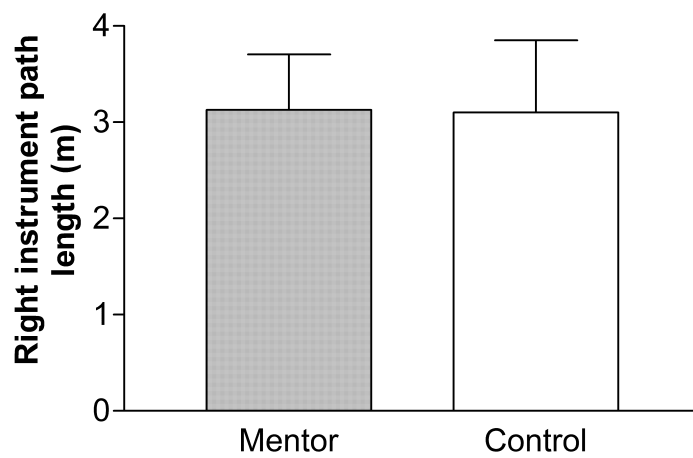


Figure 14. Basic simulator performance across groups. Study IV.

5.2.2 Mental rotation test-A

The MRT-A scores were similar comparing residents in study II and III and consultants in study I, see Figure 15.

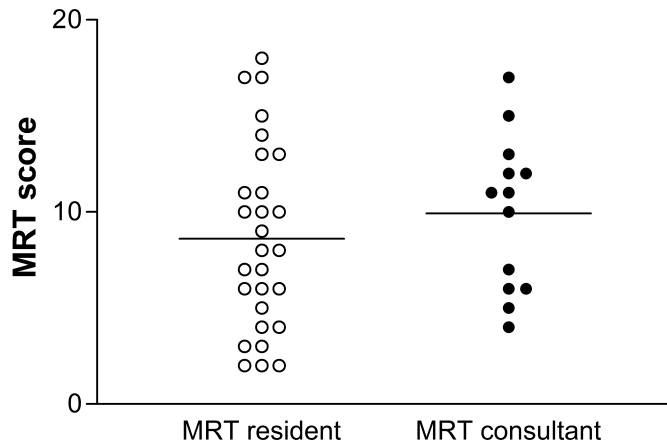


Figure 15. MRT-A scores across groups. Study I & II.

5.2.3 Flow and Self-efficacy

In study II, a four-category flow scale was used. However, in study III and IV only the factors most relevant for flow were analyzed [79]; enjoyment and concentration. When re-analyzing the flow experience in the second study, once again, using only these two flow parameters, a stronger correlation between flow and the simulator performance, than reported in study II was identified. This re-analysis was conducted in order to allow a comparison of flow scores across the different groups.

In study IV, we detected no apparent difference in flow scores across groups. However, focus group interviews suggested that the control group felt *enjoyment* whereas the mentor group was more *concentrated*, both components of flow. Flow scores after simulator training were similar for residents in study II and students in study IV, see Figure 16.

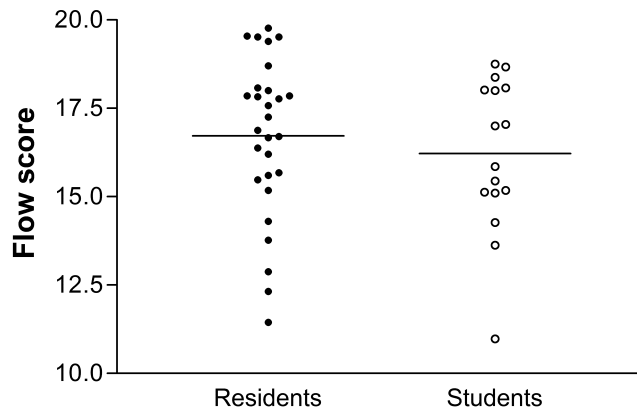


Figure 16. Flow score after basic simulator training across groups. Study II & IV.

Self-efficacy was enhanced after simulator training, as compared before training, for both residents and students (papers II & IV).

5.2.4 Mentor effect

In study IV, the group receiving structured mentorship used a shorter instrument pathway compared to the control group. The mentor group felt that they received enough support and feedback, however some individuals thought the mentor was too passive and other thought that the mentor actually made them too passive. The control group expressed lack of support and feedback.

5.2.5 Focus group results

The results of the qualitative content analyses with codes and themes are illustrated in Table 1 below.

Themes	Codes	
	<i>Mentor group</i>	<i>Control group</i>
<i>Feedback/Mentor</i>	Result improving every time Supportive, Passive Pressure to do well	Lack of feedback Introduction; informative illustrative Lack of support
<i>Learning</i>	Understanding the procedure	Instrument handling
<i>Experience/Simulator</i>	Concentrated Want to succeed and be acknowledged Authentic Pressure to save the patient	Fun and exciting Want to be seen Get support Authentic Pressure to stop the bleeding

Table 1. Codes and themes. Study IV.

6 DISCUSSION

6.1 METHODOLOGICAL CONSIDERATIONS

6.1.1 Participants

In the first study a group of OBGYN consultants was included. The aim was to investigate visuospatial ability in association with *gynecological* laparoscopic performance. Furthermore the aim was to investigate if consultants in OBGYN, as well as residents, would benefit from simulator training. In study II and III the aims were to evaluate simulator training and non-technical factors in relation to laparoscopy in order to develop a curriculum for OBGYN residents. In study IV, medical students were selected as our study population. This particular group was unexposed to laparoscopy and had little or no prior experience of simulated laparoscopy.

6.1.2 Internal validity

Internal validity refers to if we are measuring what we are supposed to. Two types of errors can affect internal validity; random errors and systematic errors. The risk of random errors is larger in studies on small samples. Limitations in the studies in this thesis are the fairly small sample sizes. One type of systematic error is selection bias. Selection bias refers to the participants in the study and their validity. For example, if we want to investigate the effect of simulator training on laparoscopic performance by comparing trained and untrained groups it is important that prior experience of simulator training and laparoscopic skills are equal across groups at baseline. Prospective and randomized trials run lesser risk of selection bias. All four studies in this thesis are prospective. The first two studies consist of cohorts whereas the last two studies are randomized trials, thus minimizing the risk of selection bias.

6.1.3 External validity

In study I, I believe subjects were representative for the group of consultants working in small-sized hospitals in Sweden, where all consultants perform laparoscopies, albeit infrequently. These consultants typically performed between a few operations per week to only a few operations per month.

Studies II and III, included 28 out of the approximately 100 residents fitting the inclusion criteria, in Sweden, at the time. The majority of these residents were in their first or second year of their residency. The median age; 32 years (range 25-48) is high compared to international age spans, but reflects the Swedish setting. In paper IV, we included 16 out of 20 medical students assigned to the undergraduate course in OBGYN at campus Huddinge. The age span was small and the gender and prior experience from simulator training and laparoscopic training (none) were similar across groups.

6.1.4 Loss to follow up

In study III, 20 of the 28 participants in the study performed the first tubal occlusion following training, (7 from the control group and 13 from the two trained groups), 13 performed the second operation (5 from the control group and 8 from the two trained groups) and finally, 12 participants performed the third tubal occlusion (5 from the control group and 7 from the two trained groups). For details, see figures in paper III.

The loss to follow up in study III was in part due to organizational and logistical failures. During the course of the study, some of the residents were rotated from the OR and in some cases the operations were cancelled. In a few cases, there were technical problems, resulting in failure to record. Unfortunately the opportunities for surgery for residents in OBGYN at most clinics in Sweden are few and far between, which was the main reason why so few of the participants managed to perform three tubal occlusions following simulator training within the time-frame of the study.

6.1.5 Simulator training and performance

The simulator used in the four studies was a LapSimGyn®, which is a validated simulator with proven construct [40, 77] predictive validity [41-43] and full gynecological procedures, located at the Center for Advanced Medical Simulation and Training (CAMST), Karolinska University Hospital, Stockholm, Sweden.

The tasks and parameters evaluated in the studies were:

Paper I.

The tasks performed were “tubal occlusion” and “salpingectomy”. The parameters used were total time, score and ovarian diathermy damage.

Paper II.

The tasks performed were “tubal occlusion”, “salpingectomy”, “lifting and grasping”, “cutting” and “clip applying”. The parameters evaluated for basic performance were right and left instrument path lengths and angular paths in the task “lifting and grasping”. Simulator performance after two days of training was measured by the numbers of trials conducted to reach credential levels (sessions until passed course) in all tasks and in task “lifting and grasping”.

Paper III.

The tasks performed were “tubal occlusion”, “salpingectomy”, “lifting and grasping”, “cutting” and “clip applying”.

Paper IV.

The tasks performed were “tubal occlusion” and “salpingectomy”. The parameter evaluated was right instrument path length.

The first study aimed to investigate consultants’ performances in full gynecological simulated procedures. Therefore “tubal occlusion” and “salpingectomy” were chosen. The focus of simulator training has primarily been on novices. Depending on the consultants experience and the frequency by which they practice, it is reasonable to believe that they (and their patients) also benefit from practicing simulated laparoscopy.

In the second and third studies, a set of tasks set to an evaluated predefined credential level was used [40, 78], in order to get sufficient training. In the fourth study, the aim was not only to train the students in the simulator, but also to allow them to understand and learn a full gynecological procedure. For this purpose, the simulated salpingectomy task was chosen.

Total time, or duration of surgery, is a parameter commonly used for evaluating surgical performance, both in the simulator and in clinical laparoscopy [36, 38, 40, 41, 43].

The term “score” used for evaluating simulator performance here is the equally weighed score of all the parameters measured by the simulator. However, it can be argued, that all the parameters included are not as representative or important, for illustrating the actual performance. Therefore particular parameters, more representative for the performance, *e.g.* instrument handling as ovarian diathermia damage and instrument path lengths, were also investigated.

Paper I evaluated the more “robust” score and total time as well as the more specific ovarian diathermia damage. The latter parameter was analyzed to capture more specific skills.

Paper II evaluated instrument handling in the most difficult task; “lifting and grasping” in order to capture differences between individuals when assessing the association between basic laparoscopic performance and flow.

To evaluate simulator performance after two days of training, the numbers of trials conducted to reach credential levels (sessions until passed course) were counted in all tasks and specifically in the most difficult task “lifting and grasping”.

In paper III the same simulator tasks were conducted for baseline testing and for training. However, the simulator performance was not evaluated in this study.

6.1.6 Laparoscopic performance

6.1.6.1 *Duration of surgery*

Duration of surgery is a widely used parameter to evaluate laparoscopic performance [36, 38, 41, 43]. One can argue that time is not important and that a short duration of surgery, if jeopardizing safety, can in fact cause harm to the patient. However, studies indicate that a longer time in surgery or under anesthesia, as demanded by laparoscopy, is not beneficial for the patient [85]. Therefore an aim is always to keep time in surgery short. Moreover, for evaluating surgery this is the only truly objective measure that is accessible, other than mortality and morbidity. In study III, no complications or pregnancies were reported within the time frame of the study.

6.1.6.2 *Inter-rater agreement*

Inter-rater agreement, or inter-rater reliability, is a measure used to compare several raters' subjective scoring of, *e.g.* laparoscopic performance. These raters are usually independent of one another and also blinded to the status of the subjects. Video recordings of the surgery are commonly used to evaluate performance guided by a validated rating scale [36, 41, 43, 74].

In study III, two independent raters investigated laparoscopic performance among the group of residents. A pre-evaluated rating scale, task originally designed for salpingectomy [86], was used, but adapted for tubal occlusion in this study.

According to consensus, the inter-rater agreement as calculated by the gamma coefficient and Kendall's Tau should exceed 0.8. In this study, values in our analyses, on the different items rated according to the scale, only ranged between 0.30 and 0.70. Potential explanations for these low levels of agreements are that the raters were not sufficiently trained in grading performances or that the scale was task-adjusted and therefore no longer served its purpose. The adapted scale did not include the three items specific for salpingectomy, but was otherwise identical to the reported scale. In previous studies, it is often unclear how independent raters were of one another and therefore objectivity can be questioned. Moreover more relevant outcome measures would be morbidity and mortality.

6.1.7 Mental rotation test-A

The MRT-A is a test commonly used in cognitive science, which reliably measures visuospatial ability in individuals [53].

Several studies report that MRT scores correlate with performance in complex surgical [87] and complex laparoscopic simulator tasks [17].

6.1.8 Flow

There are different validated scales for evaluating flow, as well as components of flow. In study II, a validated four-component scale was applied. In the subsequent studies, III and IV, a two-component scale was used. Concentration and enjoyment were measured in these latter studies. These two components are the most relevant factors to assess in order to capture flow, as previously described by Ghani and Despander [79]. However, one can argue that this type of scale will not always accurately capture the experience of flow. In study IV, the participants expressed flow in terms of concentration and enjoyment in the focus interviews that differed across groups. The flow-scale did not capture these differences, but open questions did.

Flow is a state or experience, which cannot be measured before entering an activity, and is measured after, and therefore the direction of causality can be difficult to interpret.

6.1.9 Self-efficacy

Different self-assessing scales are used to measure self-efficacy. General self-efficacy, GSE is defined as “one’s belief in one’s overall competence to effect requisite performances across a wide variety of achievement situations” or as “individuals’ perception of their ability to perform across a variety of different situations” [88]. We adopted the more task-specific approach towards self-efficacy, first described by Bandura [61]. A validated [67] procedure- adjusted scale, previously used by our research group, was selected for assessing self-efficacy in papers II-IV.

6.1.10 Qualitative method

6.1.10.1 *Rationale for choosing a qualitative method*

As already described, mentorship is controversial. How, if and how often feedback should be provided during a training session has for instance not been established. Moreover, students' experiences of the learning situation in a laparoscopic simulator with and without a mentor had, to the best of our knowledge, not been investigated. Consequently an important aim was to evaluate this potential facilitator of learning by exploring students' unbiased views on mentorship.

6.1.10.2 *Trustworthiness*

Trustworthiness is important in both quantitative and qualitative research. The former has been addressed above in this section, I will thus comment exclusively on aspects of trustworthiness of the qualitative method used in paper IV.

Trustworthiness in qualitative research contains the three concepts *credibility, dependability and transferability* [84], which correspond to the quantitative concepts of *internal validity, reliability* and *external validity*. The credibility and transferability are discussed in section 6.1.1.1 and 6.1.1.2.

6.1.10.2.1 *Dependability*

The *dependability* concerns consistency of data collection and analyses, *i.e.* if these results can be repeated with this or other methods. The focus group is supposed to be exploratory. Open questions are asked to receive unexpected or unbiased answers. The two groups, interviewed individually, were consistent concerning some issues addressed, *e.g.* face validity of simulator, what to expect from mentor, the importance of feedback, that similar results would probably occur in a repetitive study. The data from interviews were transcribed and analyzed independently by two researchers, who created similar codes, themes and interpretations.

6.1.10.2.2 *Reflexivity*

Reflexivity deals with the relationship between the researcher, the interviewer and the participants, and the potential risk of affecting outcome. In study IV, a

researcher with no prior connection to the students but familiar with focus group interviews, interviewed the students.

6.1.11 Statistical considerations

When comparing small groups or correlating small samples there is always a risk not being able to reject the null-hypothesis due to a lack of power, (type II error). Also, random errors can lead to over-interpretations of the results, (type I error). Even though most of our data variables in these samples were continuous and normally distributed we chose, in the third and fourth study, to use solely non-parametric tests in order to, if possible, avoid random error.

Power estimates were made based on effect sizes observed in prior similar studies, when possible. However in the third study, the intention was to evaluate mentorship by using three different groups, power could not be estimated.

Unfortunately a large number of individuals were lost to follow up.

The original plan was to expand the study to include an additional 30-60 residents in the study, in order to reach sufficient power. However, the particular procedure, tubal occlusion, used in this study is no longer available, to residents in Sweden, to the same extent as during the start of the study. At several clinics, patients have to pay the full cost of the procedure by themselves, and at other clinics the procedure is no longer offered. The reasons for this are in part due to altered priorities among different procedures and in part due to new methods emerging [89].

6.1.12 Ethical considerations

The regional Research Ethics Committee of Stockholm approved of the four studies. Participation was voluntary. Informed consent was obtained from the participants. Confidentiality was fulfilled. No conflict of interests between participants in relations to their clinical work, benefits or grades and the research team existed.

6.2 GENERAL DISCUSSION

This thesis demonstrates that visuospatial ability, as measured by the mental rotation test, correlated with performance in early gynecological laparoscopic simulator performance as well as in early laparoscopic performance (papers I-III). According to the observations in the thesis, simulator training appeared to enhance self-efficacy and flow (papers II & III). Moreover, the findings suggest that laparoscopic performance was improved by simulator training in LapSimGyn® with, or without, structured mentorship and by increased flow and self-efficacy among the trainees (paper III). Furthermore, mentorship with feedback influenced laparoscopic simulator performance (paper IV).

Should everyone perform laparoscopic surgery?

Previous studies have suggested that surgical aptitude should be tested [90]. As a practicing Swedish gynecologist at hospitals with emergency wards that offer benign gynecological surgical procedures, you are expected to perform, *for example* laparoscopic salpingectomy whenever ectopic pregnancies or ovarian cysts need surgical treatment. This situation applies to all residents and most consultants, at least during the earlier stages of their careers. That every OBGYN resident and consultant should perform laparoscopy is also motivated by the fact that visuospatial ability could be trained or at least be compensated for by systematic simulator training. Paper III demonstrated that when training over an extended period of time, to a pre-defined credential level, the performance in the simulator appeared to be independent of the visuospatial ability, *i.e.* potentially anyone can reach the “expert level”, with the right number of repetitions in the simulator. This finding is in line with that of Wanzel *et al.* [87], who reported that surgical residents that scored lower on the MRT, initially performed poorer in spatially-complex surgical procedures, as compared to those with higher scores, although equally well after practicing.

However, the question arises how often a laparoscopic procedure needs to be performed by the surgeon to maintain an acceptable level of skills. We now have strong evidence that simulator training improves laparoscopic performance, at least among novices [36, 38, 41, 43], see also paper III. Simulator training might

also be an alternative for real surgical training for residents and consultants in circumstances that preclude frequent laparoscopies. In fact, other means by which surgeons can maintain the technical skills have been proposed. Several studies suggest that computer and video game playing can improve not only simulated [91, 92] but also real laparoscopic performance [93]. Therefore, computer and video games, today available in most households, can complement the far more inaccessible medical simulators.

In addition, non-technical factors also need to be considered when constructing a surgical curriculum. Previous studies have reported behavior-rating systems for surgeons, and also entire OR teams, based on skills, such as situation awareness, decision-making, communication and leadership [94]. The introduction and application of such systems appear to be beneficial for safe surgical practice [95-98].

However, less attention has been given to non-technical factors that might have direct effect on both simulated and real laparoscopic performance. This thesis, addresses if self-efficacy and flow, previously reported to affect performance in other fields [61, 65], also affect simulator and real laparoscopic performance. Findings in paper II suggest that self-efficacy and flow correlate to the simulated laparoscopic performance. This finding is in line with that of Maschuw *et al.*, who reported that a low self-efficacy is associated with poor simulated laparoscopic performance [64]. Results in paper II-IV, suggest that self-efficacy improve after simulator training. Observations in paper III indicated that the simulator trained groups scored higher on self-efficacy and flow while performing real laparoscopy. One interpretation of these observations is that laparoscopic simulator training enhanced self-efficacy and flow in subsequent laparoscopic surgery. Moreover, in paper III flow was significantly correlated, and self-efficacy tended to ($p < 0.058$) correlate, with laparoscopic performance, across all individuals studied. The direction of causality is difficult to interpret, since, for example, flow is assessed after surgery. However, it seems plausible that the flow measured reflected the experience during rather than after surgery. These findings suggest a reciprocal

influence between flow as well as self-efficacy and laparoscopic performance, regardless of simulator training.

Observations in Paper IV indicate that mentorship with feedback is effective when learning laparoscopy in a simulator. However, it remains somewhat controversial if mentors are good or bad and how active they should be in terms of interactions with the students [30, 73-76]. In study IV, the students expressed that feedback, support and acknowledgement were important in the learning process. Some of the students in the mentor group demanded a more active mentor and others stated that the mentor effect was pacifying. A recent study by Strandbygaard *et al.* report that medical students receiving flexible feedback during a simulated laparoscopy, while training to a predefined expert level, had a significantly shorter duration of surgery and fewer repetitions to reach the credential level, than the control group, that did not receive feedback. However, the majority of students in the control group reached the credential level and did so with a higher performance score (probably due to the fact that these students used more time and repetitions) [99].

The issue of how mentorship and feedback should be provided in the operating room is more complicated, since several other factors need to be considered, most importantly patient safety. The mentors' knowledge, teaching skills, technical skills and willingness to "hand over the knife" are all factors that will inevitably obstruct or facilitate learning among trainees. Mentors also need education in order to safely teach surgical skills and feel comfortable in "letting go of the knife". Over the past few years, requirements posed by governments and other institutions have increased the demand for professionalism among medical educators, due to demand for effective education and patient safety [100]. In the UK there are formal requirements for accreditation of all doctors with a formal responsibility for clinical teaching. As a consequence of this, instruments to evaluate supervisors are currently being developed [101].

Finding a balance between doctors' training and patients' safety demands a more structured approach to our surgical education. Such an approach must include;

training of technical skills, continuous assessment of skills, mentorship with feedback, assessment of mentor skills [102] and also attention to non-technical skills.

6.3 CONCLUSIONS, IMPLEMENTATIONS AND FUTURE PERSPECTIVES

This thesis suggests that visuospatial ability correlates with early gynecological simulator performance and gynecological laparoscopic performance. Findings furthermore indicate that self-efficacy and flow are enhanced by simulated laparoscopy and improve real laparoscopy. Results also suggest that simulator training, with or without mentorship, improve laparoscopic performance. Finally, findings in this thesis indicate that mentorship with feedback improve simulated laparoscopy and play an essential part to medical students in simulator training.

In conclusion testing visuospatial ability can be useful when designing and individualizing laparoscopic training. Simulator training, supportive mentorship with feedback, self-efficacy and flow are all tools or factors that have the potential to facilitate learning in gynecological laparoscopy.

How can these factors be implemented and fostered in the learning process? When aiming to facilitate learning you have to look at the larger picture or the wider perspective. How can you foster skills, flow or self-efficacy and above all patient safety if the environment in the operating room is hostile [103] or if the mentor never hands over the knife?

I believe that simulator training to a pre-defined, *e.g.* expert level with personalized supportive feedback followed by subsequent laparoscopic procedures in the OR, with an engaged mentor and supportive OR staff, can facilitate self-efficacy and flow and therefore facilitate learning. Inter-disciplinary and inter-occupational training with, *e.g.* human patient and laparoscopic simulators, can potentially be used to prepare students and OBGYN-residents even better for the OR experience.

Further research need to explore how to educate mentors, how feedback should be delivered, and how to boost self-efficacy and flow in clinical practice. The largest hurdles are probably organizational.

Finally, I believe that creating an environment that fosters flow and self-efficacy in students and mentors, in and out of the OR, facilitates learning in laparoscopic gynecology. This might also lead to a good life [5], hence, go with the flow.

7 POPULÄRVETENSKAPSKAPLIG SAMMANFATTNING

7.1 BAKGRUND

Lärandet påverkas av individuella förutsättningar, tidigare teoretiska och praktiska kunskaper samt inte minst lärandemiljön, inkluderande mentorer (handledare).

Lärandet och utbildning inom kirurgi är nödvändig och viktig eftersom den påverkar patientsäkerheten.

Traditionellt har den kirurgiska utbildningen skett med den så kallade "Halsted metoden"; "see one, do one, teach one". Träningen har skett direkt på patienten och mentorn har ibland själv varit oerfaren.

Rapporten "To Err is Human" ("att fela är mänskligt") släpptes 1999. Här rapporterades att 45.000-100.000 amerikaner dör varje år till följd av vårdrelaterade misstag. Allmänheten och media i USA reagerade starkt på rapporten och president Bill Clinton tillsatte genast en utredning med uppdraget att snabbt komma med rekommendationer för att förbättra bristerna i patientsäkerheten.

En gynekolog fördelar sina arbetsinsatser på mottagning, avdelning, operation, förlossning och mödravård. Detta innebär att operationstillfällena för en gynekolog är färre än för kollegor i de flesta andra kirurgiska specialiteter. Därför är det av extra stor vikt att gruppen gynekologer får kirurgisk träning.

Titthålskirurgi (laparoskopi) är en metod där man via minimala (0.5-1.5 cm) snitt tittar in i buken med hjälp av en kamera och opererar via s.k. portar. Denna minimalistiska metod innebär fördelar för patienten, jämfört med öppen eller traditionell kirurgi. Titthålskirurgi medför kortare sjukvårdsvistelse, kortare sjukskrivning och diskretare ärr. Dagens rutinvård kräver att gynekologer behärskar titthålstekniken.

Tekniken vid titthålskirurgin ställer andra krav på operatören jämfört med öppen (traditionell) kirurgi. Ett sådant krav är att man konverterar den tvådimensionella bild man ser på skärmen (där kamerabilden är projicerad) till en tredimensionell verklighet. Detta kan vi göra med hjälp av vår *visuospatiella förmåga*. Det är därför

rimligt att tro att denna förmåga påverkar vår prestation i simulatorn och vid titthålskirurgi.

På 1980- talet började innovativa lärare inom medicin inse att träning utanför operationssalen var av värde för patientsäkerheten. Initialt använde man sig av så kallade "svarta lådor", där kamera med ljus och instrument infördes och fiktiva operationer utfördes. Dessa lådor utvecklades snabbt till mer avancerade simulatorer. Träning med hjälp av simulatorer visade sig ha positiva effekter på lärandet vid titthålskirurgi och därmed också på patientsäkerheten. Simulatorn ger en mer autentisk operationssituation än den svarta lådan samt ger feedback via olika parametrar som mäts. Parametrar som mäts i simulatorn är t.ex. operationstid, blödningsmängd och hur man rör sina instrument. Den praktiska implementeringen av *simulatorträning* har skett framförallt under det senaste årtiondet. Flera olika gynekologiska operationer, som sterilisering (tubal occlusion) och borttagande av äggledare (salpingectomy) erbjuds i exempelvis LapSimGyn® simulatorn. Dessa två simulerade ingrepp användes i studierna i avhandlingen.

Utöver simulering finns andra sätt att stimulera lärandet. Studier har visat att olika psykologiska faktorer påverkar lärandet. *Self-efficacy* eller självförtroende, tron på den egna förmågan att kunna utföra en viss procedur eller hantera en viss situation (ett matteprov, en fotbollsstraff eller en operation), är en sådan faktor. Upplevelsen av *flow*, känslan av att vara totalt absorberad, koncentrerad, känna sig utmanad och fylld av glädje, är en annan sådan faktor.

Mentorskap med feedback verka också påverka lärandet inom titthålskirurgi, dock är det fortfarande oklart vilket mentorskap som ger god effekt och hur feedback bör ges.

Varken visuospatiell förmåga, self-efficacy, flow eller mentorskap med feedback hade, såvitt vi visste, undersökts i samband med gynekologisk simulatorträning eller titthålskirurgi.

7.2 SYFTE

1. Att undersöka om visuospatiell förmåga påverkar det simulerade gynekologiska resultatet samt resultatet vid titthålskirurgi.
2. Att undersöka om self-efficacy och flow är relaterade till simulatorprestationen samt prestationen vid titthålskirurgi.
3. Att undersöka om mentorskap med feedback påverkar resultatet vid simulering samt vid titthålskirurgi.
4. Att med s.k. gruppintervjuer undersöka studenters åsikter angående mentorskap för att försöka att fånga idéer och uppslag till hur mentorskapet ska struktureras.

7.3 MATERIAL OCH METODER

Deltagare i studierna var specialister eller ST-läkare i gynekologi och obstetrik eller studenter på läkarlinjen.

Visuospatiell förmåga mättes med hjälp av mental rotation test A.

Self-efficacy och flow mättes med olika frågeformulär. De kategorier av flow som mättes var glädje samt koncentration.

Simulatorträningen utfördes i LapSimGyn® på CAMST (Center for Advanced Medical Simulation and Training), Karolinska Universitetssjukhuset, Stockholm samt på Södertäljesjukhus, Södertälje. Simulatorprestation utvärderades genom mätning av bl.a. operationstid och hur långt instrumenten förflyttades.

Laparoskopisk sterilisering (tubal occlusion) var den titthålsoperation som utfördes. Den laparoskopiska prestationen utvärderades genom att mäta operationstiden.

7.4 RESULTAT

Studie I & II visade att visuospatiell förmåga korrelerade med prestationen i simulatorn under de första simulatorövningarna.

Studie II visade att self-efficacy och flow korrelerade till simulatorprestationen både initialt och efter upprepade träning.

Studie III visade att simulatortränade grupper uppgav högre flow och self-efficacy jämfört med icke tränade grupper, när de utförde titthålskirurgi.

Simulatortränade grupper använde hälften så lång tid (6 min) som otränade (13 min) för att utföra en sterilisering.

Studie IV visade att studenter som fick feedback av en mentor använde kortare instrumentväg (4 m) jämfört med gruppen som opererade självständigt (6 m).

Studenterna uttryckte att det var viktigt att få bekräftelse och stöd.

Mentorgruppen var mer koncentrerad, medan den självständiga gruppen uttryckte mer glädje.

7.5 SLUTSATSER

Simulatorträning med strukturerad mentor i en lärandemiljö som tar hänsyn till visuospatiell förmåga och förstärker self-efficacy samt flow verkar leda till bättre utförda titthålsoperationer. Att konstruera lärandemiljöer med simulatorträning, tillgång till strukturerade mentorer, som stärker möjligheterna till ett ökat self-efficacy och flow verkar därför kunna öka patientsäkerheten.

8 ACKNOWLEDGEMENTS

In addition to all the students, residents and consultants taking part in the studies in my thesis, I would like to express my gratitude towards;

Lars Enochsson, my main supervisor, for guiding me through the narrow woods and deep swamps of science, your knowledge, enthusiasm, availability and never ending good sense of humor.

Li Felländer-Tsai, my co-supervisor, for your professional and strategic advices and being a role model.

Henry Nisell, my co-supervisor, for asking the questions no one else dares to ask and being a mentor and a friend.

Carsten Rasmussen, my co-supervisor and mentor, for introducing me to and illustrating the art of laparoscopy.

Leif Hedman, co-author and collaborator, for enlightening discussions about psychological factors, essence of life and the fantastic laughter you have.

Maria Weurlander for opening the door to the other side- qualitative research. I'm intrigued.

Marie Krueger for being my mentor and given my advice on essentials in life.

Former and present heads of Obstetrics and Gynecology Departments at Karolinska University Hospital, Huddinge; **George Evaldsson**, **Lennart Nordström**, **Karin Petersson**, **Marianne van Rooijen** and **Masoumeh Rezapour** and at Södertälje hospital; **Lennart Rosenborg**, **Gabor Sebestyen** and **Sven Klaesson** for making my research possible and believing in me.

Lennart Rosenborg, **Robert Hahn** and **Nanna Waldréus**, the research unit at Södertälje hospital for your support and invaluable advice.

Magnus Westgren, head of division of Obstetric and Gynecology and **Mats Blennow**, director of studies, CLINTEC, KI for your support and availability.

Galina Drozdova, **Hélène Jansson**, **Agneta Wittlock** and **Ann-Charlott Nordström** for precious administrative help.

Lars-Gunnar Andersson, **Armand Sadeghi**, **Lars Särnå** and **Tomas Askerud**, for invaluable technical advice and support during my research and during simulator courses at Center for Advanced Medical Simulation and Training (CAMST).

Pelle G Lindqvist, director of undergraduate studies and **Elle Wågström**, director of residential studies at division of OBGYN, CLINTEC, KI and Karolinska University Hospital Huddinge, for facilitating education and my research.

Johan Creutzfeldt, my avatar in real world thesis defense.

Lars Henningsohn, Ann Kjellin, Bo Westman, Mats Hedsköld, Petter Westfelt, Marie Hult and Radmila Mrnjevic for support, collaboration and good laughs at CAMST.

All my dear co-workers at Södertälje hospital and prior co-workers at Karolinska University Hospital, Huddinge.

Daniel Murkes for making the simulator courses special, teaching me surgical skills and letting me in on the great Gravity.

Kerstin Wolff for being my mentor in OBGYN and a friend.

Anna Thorson Ekéus for *such* precious advice throughout this thesis and being a friend as good as they come.

Cecilia Olegård, Lotta Niska, Märy Lunström, Evelina Sande, Helena Skolling, Christina Bries, Monica Yttergren and Eva Ferndahl for no matter what.

Sharon & Bill Westra, Sue & Steve Anderson, Elizabeth & Gary Almeter for providing real love when travelling in unknown country without flow.

Anna-Sofia Melin, Anna Maria Jonsson, Helene Haesert de la Motte, Fariba Zhaeentan (for introducing real love), **Johanna Isaksson** and **Sara Sundén-Cullberg**; colleagues in arms, you are invaluable.

Lotta & Bertil Sundin, Jill Bederoff and Elisabeth Elvegård for the stimulating and supportive friends that you are.

Tami, Rich and Kathy for being my second family.

Rune & Yvonne for being the best parents in law.

Guje & Björn, my parents, for your never ending support and unreasonable love. **Pia and Johan** for being The sister and The brother.

Moster Eva, Anja and Peter for standing by me.

Ebba, Fabian & Vilmer "I've been upset and I've been down. I've been throwing things around". For being the peculiar and wonderful individuals that you are and facilitating flow in my life.

Håkan for giving me TLC when I least deserve it. You are my greatest supporter and challenge in life. Let us go with flow. SYW.

Finally, I would like to acknowledge the generous support from Södertälje hospital, Stockholm County Council (Pick Up, ALF and FoUU) and the Marianne and Marcus Wallenberg Foundation.

Stockholm, May, 2013

9 REFERENCES

- [1] Thorndike EL. The psychology of learning. New York: Teacher's College Press.; 1913.
- [2] Skinner BF. Are theories of learning necessary? Psychological Review 1950; 57: 193-216.
- [3] Bransford JDB, Ann L. Cocking, Rodney R. . How People Learn : Brain, Mind, Experience and School Washington, DC, USA National Academies Press 2000.
- [4] Biggs JT, Catherine Teaching for Quality Learning at University : What the Student Does (3rd Edition). Buckingham, GBR Open University Press 2007.
- [5] Csikszentmihályi M. Beyond Boredom and Anxiety: Experiencing Flow in Work and Play 1978.
- [6] Ericsson KA, Krampe, R.Th., Tesch-Romer, C. . The Role of Deliberate Practice in the Acquisition of Expert Performance Psychological Review 1993; Vol. 100: 363-406
- [7] Berci G, Forde KA. History of endoscopy: what lessons have we learned from the past? Surg Endosc 2000; 14: 5-15.
- [8] Peter DS, Holcomb, G.W., . History of Minimally Invasive Surgery. In: George Whitfield Holcomb KEG, Steven S. Rothenberg, editor. Atlas of Pediatric Laparoscopy and Thoracoscopy. Philadelphia, PA: Saunders Elsevier; 2008.
- [9] Litynski GS. Raoul Palmer, World War II, and transabdominal coeloscopy. Laparoscopy extends into gynecology. JSLS 1997; 1: 289-92.
- [10] Litynski GS. Endoscopic surgery: the history, the pioneers. World J Surg 1999; 23: 745-53.
- [11] Bongard F, Dubecz S, Klein S. Complications of therapeutic laparoscopy. Current problems in surgery 1994; 31: 857-924.
- [12] Wherry DC, Rob CG, Marohn MR, Rich NM. An external audit of laparoscopic cholecystectomy performed in medical treatment facilities of the department of Defense. Annals of surgery 1994; 220: 626-34.
- [13] Shushan A, Mohamed H, Magos AL. How long does laparoscopic surgery really take? Lessons learned from 1000 operative laparoscopies. Human reproduction 1999; 14: 39-43.
- [14] Aggarwal R, Moorthy K, Darzi A. Laparoscopic skills training and assessment. The British journal of surgery 2004; 91: 1549-58.
- [15] Hanna GB, Shimi SM, Cuschieri A. Randomised study of influence of two-dimensional versus three-dimensional imaging on performance of laparoscopic cholecystectomy. Lancet 1998; 351: 248-51.
- [16] Luursema J, Verwey, W., Burie, R. Visuospatial ability factors and performance variables in laparoscopic simulator training. Learning and Individual Differences 2012; 22: 632-8.
- [17] Hedman L, Ström P, Andersson P, Kjellin A, Wredmark T, Felländer-Tsai L. High-level visual-spatial ability for novices correlates with performance in a visual-spatial complex surgical simulator task. Surg Endosc 2006; 20: 1275-80.
- [18] Gallagher AG, McClure N, McGuigan J, Ritchie K, Sheehy NP. An ergonomic analysis of the fulcrum effect in the acquisition of endoscopic skills. Endoscopy 1998; 30: 617-20.
- [19] Cameron JL. William Stewart Halsted. Our surgical heritage. Annals of surgery 1997; 225: 445-58.
- [20] Anastakis DJ, Regehr G, Reznick RK, Cusimano M, Murnaghan J, Brown M, et al. Assessment of technical skills transfer from the bench training model to the human model. Am J Surg 1999; 177: 167-70.
- [21] Wakefield M. To Err Is Human: An Institute of Medicine Report. Professional Psychology: Research and Practice 2000; 31: p 243-4.

- [22] Soop M, Fryksmark U, Koster M, Haglund B. The incidence of adverse events in Swedish hospitals: a retrospective medical record review study. *International journal for quality in health care* 2009; 21: 285-91.
- [23] Scott DJ, Dunnington GL. The new ACS/APDS Skills Curriculum: moving the learning curve out of the operating room. *J Gastrointest Surg* 2008; 12: 213-21.
- [24] Hafford ML, Van Sickle KR, Willis RE, Wilson TD, Gugliuzza K, Brown KM, et al. Ensuring competency: are fundamentals of laparoscopic surgery training and certification necessary for practicing surgeons and operating room personnel? *Surg Endosc* 2013; 27: 118-26.
- [25] Scott DJ, Cendan JC, Pugh CM, Minter RM, Dunnington GL, Kozar RA. The changing face of surgical education: simulation as the new paradigm. *The Journal of surgical research* 2008; 147: 189-93.
- [26] Strom P, Kjellin A, Hedman L, Johnson E, Wredmark T, Fellander-Tsai L. Validation and learning in the ProCedicus KSA virtual reality surgical simulator. *Surg Endosc* 2003; 17: 227-31.
- [27] Enochsson L, Westman B, Ritter EM, Hedman L, Kjellin A, Wredmark T, et al. Objective assessment of visuospatial and psychomotor ability and flow of residents and senior endoscopists in simulated gastroscopy. *Surg Endosc* 2006; 20: 895-9.
- [28] Strom P, Hedman L, Sarna L, Kjellin A, Wredmark T, Fellander-Tsai L. Early exposure to haptic feedback enhances performance in surgical simulator training: a prospective randomized crossover study in surgical residents. *Surg Endosc* 2006; 20: 1383-8.
- [29] McGaghie WC. Simulation in professional competence assessment: basic consideration. *Innovative Simulations for Assessing Professional Competence*. Chicago: Department of Medical Education, University of Illinois at Chicago; 1999.
- [30] Issenberg SB, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Medical Teacher* 2005; 27: 10-28.
- [31] Zendejas B, Brydges R, Wang AT, Cook DA. Patient Outcomes in Simulation-Based Medical Education: A Systematic Review. *Journal of General Internal Medicine* 2013. 10.1007/s11606-012-2264-5
- [32] Strom P, Kjellin A, Hedman L, Wredmark T, Fellander-Tsai L. Training in tasks with different visual-spatial components does not improve virtual arthroscopy performance. *Surg Endosc* 2004; 18: 115-20.
- [33] Creutzfeldt J, Hedman L, Medin C, Wallin CJ, Felländer-Tsai L. Effects of repeated CPR training in virtual worlds on medical students' performance. 2008; 132: 89-94.
- [34] Westman B, Ritter EM, Kjellin A, Torkvist L, Wredmark T, Fellander-Tsai L, et al. Visuospatial abilities correlate with performance of senior endoscopy specialist in simulated colonoscopy. *J Gastrointest Surg* 2006; 10: 593-9.
- [35] Gallagher AG, Cates CU. Virtual reality training for the operating room and cardiac catheterisation laboratory. *Lancet* 2004; 364: 1538-40.
- [36] Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, et al. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Annals of surgery* 2002; 236: 458-63.
- [37] Schlickum M, Fellander-Tsai L, Hedman L, Henningsohn L. Endourological simulator performance in female but not male medical students predicts written examination results in basic surgery. *Scandinavian Journal of Urology* 2013; 47: 38-42.
- [38] Grantcharov TP, Kristiansen VB, Bendix J, Bardram L, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *The British journal of surgery* 2004; 91: 146-50.
- [39] Van Sickle KR, Ritter EM, McClusky DA, 3rd, Lederman A, Baghai M, Gallagher AG, et al. Attempted establishment of proficiency levels for laparoscopic performance on a national scale using simulation: the results from the 2004 SAGES Minimally Invasive Surgical Trainer-Virtual Reality (MIST-VR) learning center study. *Surg Endosc* 2007; 21: 5-10.

- [40] Larsen CR, Grantcharov T, Aggarwal R, Tully A, Sørensen JL, Dalsgaard T, et al. Objective assessment of gynecologic laparoscopic skills using the LapSimGyn virtual reality simulator. *Surg Endosc* 2006; 20: 1460-6.
- [41] Ahlberg G, Enochsson L, Gallagher AG, Hedman L, Hogman C, McClusky DA, 3rd, et al. Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies. *Am J Surg* 2007; 193: 797-804.
- [42] Cosman PH, Hugh TJ, Shearer CJ, Merrett ND, Biankin AV, Cartmill JA. Skills acquired on virtual reality laparoscopic simulators transfer into the operating room in a blinded, randomised, controlled trial. *Studies in health technology and informatics* 2007; 125: 76-81.
- [43] Larsen CR, Soerensen JL, Grantcharov TP, Dalsgaard T, Schouenborg L, Ottosen C, et al. Effect of virtual reality training on laparoscopic surgery: randomised controlled trial. *BMJ* 2009; 338: b1802.
- [44] Källström R, Hjertberg H, Svanvik J. Impact of virtual reality-simulated training on urology residents' performance of transurethral resection of the prostate. *J Endourol* 2010; 24: 1521-8.
- [45] Aggarwal R, Darzi A. Simulation to Enhance Patient Safety: Why Aren't We There Yet? *Chest* 2011; 140: 854-8.
- [46] Larsen RC. *Virtual Reality Simulation in Laparoscopic Gynaecology*. Copenhagen: Copenhagen University; 2009.
- [47] Baddeley A, Logie R, Bressi S, Della Sala S, Spinnler H. Dementia and working memory. *Q J Exp Psychol A* 1986; 38: 603-18.
- [48] Carpenter PA, Just MA. Spatial ability: An information processing approach to psychometrics. In: R.J.S., editor. *Advances in psychology of human intelligence*: Erlbaum, Hillsdale NJ; 1986. p. 221-53.
- [49] Macmillan AI, Cuschieri A. Assessment of innate ability and skills for endoscopic manipulations by the Advanced Dundee Endoscopic Psychomotor Tester: predictive and concurrent validity. *Am J Surg* 1999; 177: 274-7.
- [50] Hegarty M, Keener M, Cohen C. The Role of Spatial Cognition in Medicine: Applications for Selecting and Training Professionals. In: Allen G, editor. *Applied spatial cognition*. Mahwah, NJ: Lawrence Erlbaum Associates; 2007.
- [51] Hedman L, Klingberg T, Enochsson L, Kjellin A, Felländer-Tsai L. Visual working memory influences the performance in virtual image-guided surgical intervention. *Surg Endosc* 2007; 21: 2044-50.
- [52]
- [53] Peters M, Laeng B, Latham K, Jackson M, Zaiyouna R, Richardson C. A redrawn Vandenberg and Kuse mental rotations test: different versions and factors that affect performance. *Brain and cognition* 1995; 28: 39-58.
- [54] Klingberg T, Fernell E, Olesen PJ, Johnson M, Gustafsson P, Dahlstrom K, et al. Computerized training of working memory in children with ADHD--a randomized, controlled trial. *Journal of the American Academy of Child and Adolescent Psychiatry* 2005; 44: 177-86.
- [55] Heinzl S, Schulte S, Onken J, Duong QL, Riemer TG, Heinz A, et al. Working memory training improvements and gains in non-trained cognitive tasks in young and older adults. *Neuropsychology, development, and cognition Section B, Aging, neuropsychology and cognition* 2013. 10.1080/13825585.2013.790338
- [56] Zhuang JP, Fang R, Feng X, Xu XH, Liu LH, Bai QK, et al. The Impact of Human-Computer Interaction-Based Comprehensive Training on the Cognitive Functions of Cognitive Impairment Elderly Individuals in a Nursing Home. *Journal of Alzheimer's disease : JAD* 2013. 10.3233/JAD-130158
- [57] Barnes DE, Yaffe K, Belfor N, Jagust WJ, DeCarli C, Reed BR, et al. Computer-based cognitive training for mild cognitive impairment: results from a pilot randomized, controlled trial. *Alzheimer disease and associated disorders* 2009; 23: 205-10.
- [58] Kennedy AM, Boyle EM, Traynor O, Walsh T, Hill AD. Video gaming enhances psychomotor skills but not visuospatial and perceptual abilities in surgical trainees. *Journal of surgical education* 2011; 68: 414-20.

- [59] Enochsson L, Isaksson B, Tour R, Kjellin A, Hedman L, Wredmark T, et al. Visuospatial skills and computer game experience influence the performance of virtual endoscopy. *J Gastrointest Surg* 2004; 8: 876-82.
- [60] Schlickum M, Hedman L, Enochsson L, Henningsohn L, Kjellin A, Fellander-Tsai L. Surgical simulation tasks challenge visual working memory and visual-spatial ability differently. *World J Surg* 2011; 35: 710-5.
- [61] Bandura A. *Self-Efficacy: The Exercise of Control*. WH Freeman and company. New York. NY. 1997.
- [62] Bandura A, Locke EA. Negative self-efficacy and goal effects revisited. 2003; 88: 87-99.
- [63] Norgaard B, Draborg E, Vestergaard E, Odgaard E, Jensen DC, Sorensen J. Interprofessional clinical training improves self-efficacy of health care students. *Medical teacher* 2013. 10.3109/0142159X.2012.746452
- [64] Maschuw K, Schlosser K, Kupietz E, Slater EP, Weyers P, Hassan I. Do soft skills predict surgical performance?: a single-center randomized controlled trial evaluating predictors of skill acquisition in virtual reality laparoscopy. *World J Surg* 2011; 35: 480-6.
- [65] Nakamura J, Csikszentmihalyi, M, . *The concept of flow Handbook of positive psychology*; 2002.
- [66] Baumann NS, D. Seeking flow in the achievement domain: The achievement flow motive behind flow experience. *Motiv Emot* 2011; 35: 267-84.
- [67] Pintrich PR, Smith DAF, Garcia T, McKeachie WJ. Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (Mslq). *Educational and Psychological Measurement*. 1993; 53: 801-13.
- [68] Ahlberg G, Kruuna O, Leijonmarck CE, Ovaska J, Rosseland A, Sandbu R, et al. Is the learning curve for laparoscopic fundoplication determined by the teacher or the pupil? *Am J Surg* 2005; 189: 184-9.
- [69] McKinstry B, Macnicol M, Elliot K, Macpherson S. The transition from learner to provider/teacher: the learning needs of new orthopaedic consultants. *BMC medical education* 2005; 5: 17.
- [70] Irby DM. Teaching and learning in ambulatory care settings: a thematic review of the literature. *Academic medicine : journal of the Association of American Medical Colleges* 1995; 70: 898-931.
- [71] van de Ridder JM, Stokking KM, McGaghie WC, ten Cate OT. What is feedback in clinical education? *Medical education* 2008; 42: 189-97.
- [72] Sender Liberman A, Liberman M, Steinert Y, McLeod P, Meterissian S. Surgery residents and attending surgeons have different perceptions of feedback. *Medical teacher* 2005; 27: 470-2.
- [73] Kruglikova I, Grantcharov TP, Drewes AM, Funch-Jensen P. The impact of constructive feedback on training in gastrointestinal endoscopy using high-fidelity Virtual-Reality simulation: a randomised controlled trial. *Gut*. 2010; 59: 181-5.
- [74] Grantcharov TP, Schulze S, Kristiansen VB. The impact of objective assessment and constructive feedback on improvement of laparoscopic performance in the operating room. *Surg Endosc* 2007; 21: 2240-3.
- [75] Mahmood T, Darzi A. The learning curve for a colonoscopy simulator in the absence of any feedback: no feedback, no learning. *Surg Endosc* 2004; 18: 1224-30.
- [76] Snyder CW, Vandromme MJ, Tyra SL, Hawn MT. Proficiency-based laparoscopic and endoscopic training with virtual reality simulators: a comparison of proctored and independent approaches. *Journal of surgical education* 2009; 66: 201-7.
- [77] van Dongen KW, Tournioij E, van der Zee DC, Schijven MP, Broeders IA. Construct validity of the LapSim: can the LapSim virtual reality simulator distinguish between novices and experts? *Surg Endosc* 2007; 21: 1413-7.
- [78] Aggarwal R, Tully A, Grantcharov T, Larsen CR, Miskry T, Farthing A, et al. Virtual reality simulation training can improve technical skills during laparoscopic salpingectomy for ectopic pregnancy. *BJOG* 2006; 113: 1382-7.
- [79] Ghani JA, Deshpande SP. Task Characteristics and the Experience of Optimal Flow in Human—Computer Interaction. *Journal of psychology* 1994; 128: 381-91.

- [80] Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qualitative health research* 2005; 15: 1277-88.
- [81] Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Research in Psychology* 2006; 3: 77-101.
- [82] Elo S, Kyngas H. The qualitative content analysis process. *Journal of advanced nursing* 2008; 62: 107-15.
- [83] Morgan DL. Qualitative content analysis: a guide to paths not taken. *Qualitative health research* 1993; 3: 112-21.
- [84] Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse education today* 2004; 24: 105-12.
- [85] Reinhart DJ, Grum DR, Berry J, Lensch D, Marchbanks CR, Zsigmond E. Outpatient general anesthesia: a comparison of a combination of midazolam plus propofol and propofol alone. *Journal of clinical anesthesia* 1997; 9: 130-7.
- [86] Larsen CR, Grantcharov T, Schouenborg L, Ottosen C, Soerensen JL, Ottesen B. Objective assessment of surgical competence in gynaecological laparoscopy: development and validation of a procedure-specific rating scale. *BJOG* 2008; 115: 908-16.
- [87] Wanzel KR, Hamstra SJ, Anastakis DJ, Matsumoto ED, Cusimano MD. Effect of visual-spatial ability on learning of spatially-complex surgical skills. *Lancet* 2002; 359: 230-1.
- [88] Judge T.A. Bono, J.E. Relationship of core self-evaluations traits, self-esteem, generalized self-efficacy, locus of control, and emotional stability, with job satisfaction and job performance: a meta-analysis. *Journal of applied psychology* 2001; 86 80 -92.
- [89] Shavell VI, Abdallah ME, Shade GH, Diamond MP, Berman JM. Trends in sterilization since the introduction of Essure hysteroscopic sterilization. *J of Minimally Invasive Gyn* 2009; 16: 22-7.
- [90] Salgado J, Grantcharov TP, Papasavas PK, Gagne DJ, Caushaj PF. Technical skills assessment as part of the selection process for a fellowship in minimally invasive surgery. *Surg Endosc* 2009; 23: 641-4.
- [91] Kolga Schlickum M, Hedman L, Enochsson L, Kjellin A, Fellander-Tsai L. Transfer of systematic computer game training in surgical novices on performance in virtual reality image guided surgical simulators. *Studies in health technology and informatics* 2008; 132: 210-5.
- [92] Schlickum MK, Hedman L, Enochsson L, Kjellin A, Fellander-Tsai L. Systematic video game training in surgical novices improves performance in virtual reality endoscopic surgical simulators: a prospective randomized study. *World J Surg* 2009; 33: 2360-7.
- [93] Rosser JC, Jr., Lynch PJ, Cuddihy L, Gentile DA, Klonsky J, Merrell R. The impact of video games on training surgeons in the 21st century. *Arch Surg* 2007; 142: 181-6; discussion 6.
- [94] Wallin C-J HL, Meurling L, et al. . A-TEAM: targets for training, feedback and assessment of all OR members' team work. In: Flin R ML, editor. *Safer surgery: analysing behaviour in the operating theatre*. Farnham, UK: Ashgate; 2009. p. 129-50.
- [95] Yule S, Flin R, Paterson-Brown S, Maran N, Rowley D. Development of a rating system for surgeon's; non-technical skills. *Clinical Skills Education*. 2006; 40: 1098-104.
- [96] Yule S, Flin R, Maran N, Rowley D, Youngson G, Paterson-Brown S. Surgeon's; non-technical skills in the operating room: reliability testing of the NOTSS behavior rating system. *World J Surg* 2008; 32: 548-56.
- [97] Crossley J, Marriott J, Purdie H, Beard JD. Prospective observational study to evaluate NOTSS (Non-Technical Skills for Surgeons) for assessing trainees' non-technical performance in the operating theatre. *British J of Surg* 2011; 98: 1010-20.
- [98] Carthey J. The role of structured observational research in health care. *Qual Saf Health Care*. 2003; 12 Suppl 2: ii13-6.

- [99] Strandbygaard J, Bjerrum F, Maagaard M, Winkel P, Larsen CR, Ringsted C, et al. Instructor Feedback Versus No Instructor Feedback on Performance in a Laparoscopic Virtual Reality Simulator: A Randomized Trial. *Annals of surgery* 2013; 257: 839-44.
- [100] Swanwick T. See one, do one, then what? Faculty development in postgraduate medical education. *Postgraduate medical journal* 2008; 84: 339-43.
- [101] Archer J, Swanwick T, Smith D, O'Keeffe C, Cater N. Developing a multisource feedback tool for postgraduate medical educational supervisors. *Medical Teacher* 2013; 35: 145-54.
- [102] Grantcharov TP, Reznick RK. Teaching procedural skills. *Surg Endosc* 2008; 336: 1129-31.
- [103] Leape LL, Shore MF, Dienstag JL, Mayer RJ, Edgman-Levitan S, Meyer GS, et al. Perspective: a culture of respect, part 1: the nature and causes of disrespectful behavior by physicians. *Academic medicine*. 2012; 87: 845-52.